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THE EFFECT OF ALUMINA ON THE MELTING RATE[1] OF A SODA-LIME-MAGNESIA-SILICA GLASS

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THE beneficial effects of small amounts of alumina on the resistance to devitrification of ordinary glasses have long been recognized. Alumina appears in small amounts in most glasses as the result of impure raw materials, intentional additions, or by the corrosion of the refractory containers in which the glass is melted. A recent trend in glass making is to add this constituent intentionally by the use of feldspar or some other alumina-bearing material to increase the percentage of the oxide in the resulting glass.

This practice brings to the fore many questions concerning the manufacture and the properties of such glasses, among which is the effect on the rate of melting. This paper deals only with the effect on the melting rate at 1200°C, 1250°C, 1300°C, and 1400°C, when additions of alumina up to eight per cent are made to a soda-lime-magnesia-silica glass.

Although there are no quantitative data concerning the effect of alumina on the melting rate of glasses, a number of comments on the fusibility of such glasses have been made by various investigators and others interested in the problem.

The Effect of Alumina on the Fusibility

Singer[2] found that the addition of pegmatite to a typical soda-lime-silica glass gave distinctly more fusible melts. In glasses containing a higher percentage of lime than ordinarily used, the beneficial effect increased; the silica content was found to limit the range in which the fusibility was increased. Kaolin[3] and aluminum hydroxide yielded similar results. Singer's procedure, in determining the fusibility, was to heat crucibles containing the glass batches to definite temperatures, chill them to room temperature, and examine for unmelted material.

Springer,[4] using the same base glass as Singer, removed samples from a clay crucible on an iron rod during the melting process and found:

(a) Kaolin decreased the fusibility of the normal high alkali glass.

(b) The fusibility of a high lime glass was increased by the addition of kaolin.

Turner[5] found that when one-tenth equivalent of alumina replaces a similar amount of lime in the following glass:

$$1.1\ Na_2O \cdot 0.9\ CaO \cdot 6.0\ SiO_2,$$

it could be melted more easily than the base glass, and workable melts could be obtained with replacements up to three-tenths equivalents.

McBerty[6] found, by microscopic examination, that aluminum hydroxide was more easily dissolved in batches containing soda ash than was feldspar; the reverse was found with salt cake batches. The progress of melting was followed by removing samples with a silica rod.

Effects of Alumina on Devitrification Temperature

Morey[7], studying the effects of additions of alumina on the devitrification conduct of the following glass:

Na_2O	14.3%
CaO	11.0%
SiO_2	74.7%

found the liquidus temperature was lowered 30°C, by the addition of two per cent of alumina, and that the liquidus temperature of all glasses containing up to five per cent alumina, were lower than the parent glass.

Morey has shown also that the addition of alumina causes the primary phase of the above glass to change from tridymite to devitrite and with still further addition to change from devitrite to wollastonite.

Morey[8], found that the addition of sufficient alumina to the glass:

Na_2O	11.82%
CaO	16.03
SiO_2	72.15

so that the final composition contained 1.29% alumina, raised the liquidus temperature 22°C.

Turner and his associates[9] state that silica is the last constituent to go into solution in the melting of a soda-lime-silica glass.

Littleton[10], referring to a paper given by Day in 1931, gives data on the melting of a soda-lime-silica glass. The melting was carried out in platinum. The results are shown clearly in Fig. 1.

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[1] The term "melting" refers to the process in which the glass batch is transformed to a homogeneous fluid. The phrase "rate of melting" as used in glass technology, would be expressed more exactly by "rate of solution;" and the terms are used interchangeably in this paper.

[2] Singer, F., The influence of alumina on the fusibility of glasses. Ker. Rund. (5, 1915).

[3] Singer, F., The influence of alumina on the fusibility of glasses. Ker. Rund. (142, 1915).

[4] Springer, L., The influence of alumina on the fusibility of glasses. Ker. Rund. (48, 1917).

[5] Turner, etc., The influence of aluminum on the properties of glass. Jour. Soc. Glass Tech. (107, 1921).

[6] McBerty, R. K., Comparative tests of aluminm and feldspar as sources of alumina in glass. Glass Ind. (215, 1928).

[7] Morey, G. W., The effect of alumina on the devitrification of a soda-lime-silica glass. Jour. Am. Ceram. Soc. (718, 1930).

[8] Morey, G. W., The devitrification of soda-lime-silica glasses. Jr. Am. Ceram. Soc. (683, 1930).

[9] Turner, etc., The fundamental reactions in the formation of soda-lime-silica glasses. J. Soc. Glass Tech. (290, 1934).

[10] Littleton, J. T., The physical processes occurring in the melting and cooling of glass. J. Am. Ceram. Soc. (43, 1934).

Rate of Solution at Constant Temperature

THE final phenomena of melting of glasses is the solution of the last crystalline phase (not taking into consideration fining). The laws which control the solution of salts, etc., in a liquid at ordinary temperatures should be applicable to the problem of the disappearance of the final crystalline phase in glass melting, since the same physical process is involved in both cases.

The rate at which a solid will dissolve in a liquid is directly proportional to the difference between the amount capable of being in solution at that temperature, and the amount already in solution. Further, it is directly proportional to the area exposed by a given weight of the solute, and finally, it is proportional to the diffusivity of the solute in the solution. Work done at ordinary temperatures has shown that the above assumptions are essentially correct. These same factors are assumed to hold at high temperatures, in this paper.

Setting the above factors into a mathematical expression for the rate of solution at constant temperature, we have:

$$(a) \qquad \left(\frac{dx}{dt}\right)_T = KA\,(S-x)\,D^{\mu}$$

in which dx is the change of the amount of solid in the solution in the time dt, S the amount of solid capable of being in solution at the constant temperature, x the amount of solute already in solution, A is a constant related to surface exposed by the solid, D is a factor depending on the diffusivity at the temperature, and μ is power of the diffusivity.

The coefficient of diffusivity can be considered to be inversely proportional to the viscosity[11], and, for the sake of convenience, the rate of solution is considered to be a function of the first power of the viscosity.

Rewriting (a) with the above assumptions, we have:

$$(b) \qquad r = \left(\frac{dx}{dt}\right)_T = \frac{KA\,(S-x)}{\eta}$$

in which r is the rate of solution and η the viscosity. The other terms have been explained before.

Change in Rate of Solution with Temperature

The variation of the rate of solution with temperature can be found by differentiating expression (b) with respect to temperature, then:

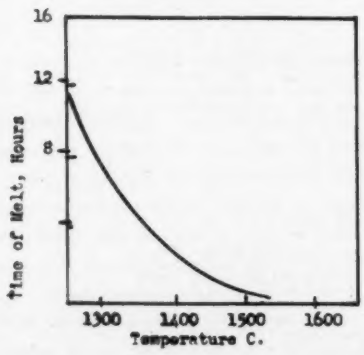


Fig. 1. Time to melt glass at various temperatures. (According to R. K. Day).

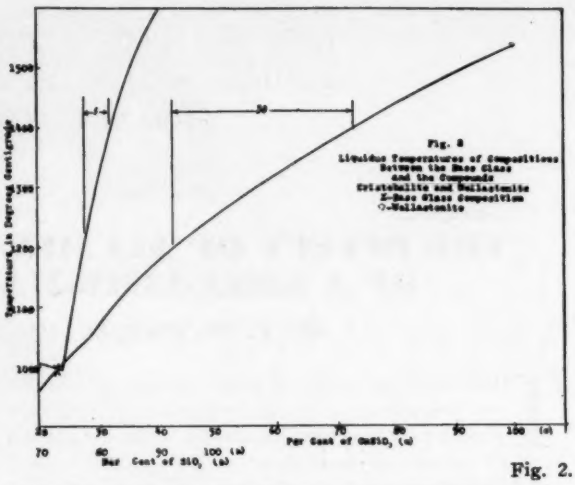


Fig. 2
Liquidus Temperatures of Compositions Between the Pure Glass and the Compounds
Cristobalite and Wollastonite
Per Cent of SiO2 (a)

Fig. 2.

$$(c) \qquad \frac{dr}{dT} = \frac{KA}{\eta}\frac{d(S-x)}{dT} - \frac{KA(S-x)}{\eta^2}\frac{d\eta}{dT}$$

in which dr is the change in rate of solution caused by the temperature change dT, A the surface factor constant, d(S—x) the change in the difference of the amount of the solute capable of being in solution and the amount already in solution which will hereafter be referred to as the increase in solubility due to the temperature change dT, η the viscosity of the solution, $d\eta$ the change of the viscosity corresponding to the temperature change dT.

This expression shows that the change of rate of solution with temperature is dependent on two factors; the rate of change of viscosity and solubility with temperature.

The magnitude of the rate of change of solubility with temperature is the slope of liquidus curve connecting the composition of the glass and the final crystalline phase; the rate of change of viscosity is the slope of the temperature-viscosity curve for the particular glass.

Rewriting the above expression, we can evaluate these factors according to their influence on the rate of solution:

$$(d) \qquad \frac{dr}{dt} = \frac{1}{\eta}\left(KA\frac{d(S-x)}{dT} - r\frac{d\eta}{dT}\right)$$

The term $\frac{d\,(S-x)}{dT}$ can be considered of little importance if the final crystalline phase is silica. Figure 2 shows the increase in solubility of silica between 1200°C and 1400° C is 5 per cent.[12]

In case the wollastonite is the final crystalline phase, this term is large compared with the increased solubility of the silica, and may be of importance as influencing the change of the rate of solution. The solubility of this compound increases so that 30 per cent more wollastonite is soluble in the glass when the temperature is raised from 1200°C to 1400°C.

In general, most glasses show a great decrease in vis-

[11] Bowen, N. L., Diffusion in silicate melts. Jour. of Geol. (295, 1921).

[12] These liquidus temperature data were obtained by connecting the glass composition with the compounds cristobalite and wollastonite from the data of Morey and Bowen. The magnesia in the glass was calculated as lime. Morey, G. W. and Bowen, N. L., The ternary system sodium metasilicate-calcium metasilicate-silica. Jour. Soc. Glass Tech. (226-1925).

cosity between 1200°C and 1350°C and above this temperature the decrease is not as great. The importance of this term, $\frac{d\eta}{dT}$, becomes greater if the rate of solution is proportional to a higher power of the diffusivity than the first. For instance, the second term of expression (d) would be multiplied by two if the rate of solution were a function of the square of the viscosity. In many cases, the change of rate of solution of salts in water with temperature have been found to be chiefly due to the change of the diffusivity; and since the increased solubility of silica in this temperature range is not particularly great, the change in the melting rate of glass, if silica is the final crystalline phase, is probably due to the change in viscosity.

Glasses Used in the Tests

THE composition of the glasses used in these tests are represented in terms of their component oxides, calculated from the batch compositions. These are given in Table I; Table II gives the batch compositions.

TABLE I

Composition of the Glasses

Glass	Na_2O	CaO	MgO	SiO_2	Al_2O_3
0	16.0	7.7	3.2	73.1	0
2	15.7	7.65	2.98	71.5	1.97
4	15.4	7.46	2.91	70.2	3.82
8	14.8	7.2	2.80	67.8	7.4

TABLE II

Batch Compositions

Glass	Sand	Sodium Carbonate	Calcium Carbonate	Magnesia	Alumina
0	205.6	77	39	8.5	0
2	205.6	77	39	8.5	5.63
4	205.6	77	39	8.5	11.20
8	205.6	77	39	8.5	22.5

The general limits of composition were:

Na_2O	14.8—16.0%
CaO	7.2— 7.7%
MgO	2.8— 3.2%
Al_2O_3	7.4— 0
SiO_2	67.8—73.1%

Preparation of the Glasses

The glasses were prepared from: C. P. Sodium Carbonate, C. P. Calcium Carbonate, C. P. Magnesium Oxide, C. P. Aluminum Hydroxide, Ottawa Standard Sand.

The sand was first washed with hydrochloric acid to remove as much as possible of the iron which coats the surfaces of the grains. All of the sand to be used for the glasses was ground at one time in a porcelain ball mill to pass through a 100-mesh screen.

The alumina was prepared by heating the hydroxide in a crucible until constant weight was reached.

The batches of sand, calcium carbonate, sodium carbonate and magnesia were weighed out separately and to each was added the desired amount of the prepared alumina. The sand used was of the same grain size in each batch to eliminate the change in melting time due to the surface factor.

Each batch was mixed mechanically for 12 hours. The uniformity of the raw base glass batch was found by analyzing four samples from different parts of the jar to determine the percentage of water soluble, acid soluble, and insoluble material. The results were sufficiently uniform to show that further mixing was not necessary.

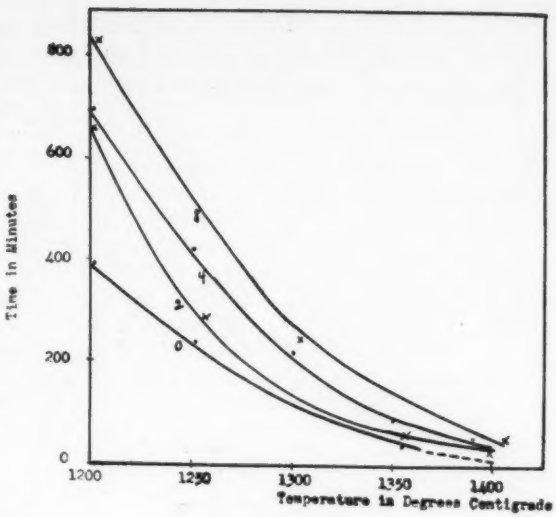


Fig. 3. Time for complete melting of the various glasses at different temperatures.

The melting of the glasses was done in two parts. The first stage was carried out at 1050°C in a chromel-wound furnace for one hour and a half to remove the carbon dioxide and to partially fuse the batch. Two hundred grams of each glass was prepared in this way to insure uniformity of composition of each sample used in these tests.

The partially fused glasses were crushed in a steel mortar to pass through a 40-mesh sieve, and the iron, which was abraded from the mortar, was removed by passing the powder over an electro-magnet several times. The last stage of the fusion was accomplished in a platinum resistor furnace.

Fifteen grams of glass were used uniformly for each test to eliminate any possible effects of the change of the weight or volume of the charge on the melting time.

A thermocouple was fixed in the furnace so that the hot junction was nearly at the level of the glass surface. The temperature of the furnace could be brought back to the desired reading in five minutes after the charge had been introduced. When the melting times were determined at 1350°C and 1400°C, the crucible had to be heated before being placed in the furnace, lest the time required to restore the desired temperature be too long.

Preliminary work had to be carried out on all the glasses and at all temperatures in order to determine the approximate melting time and thus avoid excessive removals of crucible from the furnace in the final tests. Normally, three removals were necessary under 1300°C, while two were required above this temperature.

Results of Chemical Analysis of the Base Glass Batch

Sample	Water Soluble	Acid Soluble (by difference)	Insoluble
I	20.3	18.1	61.6
II	19.8	19.4	60.8
III	21.0	17.7	61.3
IV	20.7	18.2	61.1

The melting was considered to be complete when the microscopic examination of a powdered sample of the chilled glass drawn from the crucible showed no crystalline material.

Results

The results of these tests are given in Table III and are graphically represented in Figure 3. The time-temperature curves are of the exponential type and can be approximately represented by $t = c - ae^{bT}$. By the use of proper constants for a particular glass, this formula will yield the time necessary for the disappearance of the last crystalline portion.

TABLE III

Temperature	Time	Solid Phase Present
	Glass No. O	
1200°C	390 min.	Wollastonite
1252°C	245 min.	Wollastonite
1302°C	110 min.	
1354°C	45 min.	
	Glass No. 2	
1200°C	675 min.	Tridymite
1256°C	285 min.	Tridymite
1300°C	135 min.	Tridymite
1400°	30 min.	
	Glass No. 4	
1205°C	690 min.	Tridymite
1250°C	450 min.	Tridymite
1300°C	220 min.	Tridymite
1380°C	60 min.	
	Glass No. 8	
1204°C	840 min.	
1240°C	660 min.	
1304°C	240 min.	
1350°C	95 min.	
1403°C	45 min.	

The addition of two per cent of alumina increases the melting time at the lower temperature while further additions have a less pronounced effect. At the higher temperature, the melting time is not so markedly raised; and the increase in melting time is nearly a linear function of the alumina additions. This is best shown in Fig. 4. The difference between the melting time of the four and eight per cent glasses above 1350°C is practically zero.

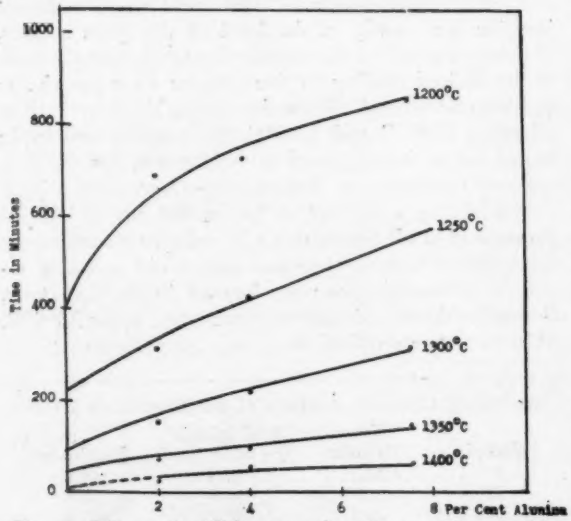


Fig. 4. Effect of additions on time for complete melting at various temperatures.

The final crystalline phase in the melting of the base glass was identified as wollastonite at 1200°C and 1250°C. The crystal phases present in the aluminous glasses were identified as cristobalite and tridymite. In all cases the tridymite predominated.

At 1350°C the base glass and the glass containing two per cent alumina were quite plain at the end of the melting period. The glasses containing higher alumina were not plain at the end of melting at 1400°C.

Since small additions of alumina are likely to depress the liquidus temperature of the base glass, and thus increase the magnitude of the difference between the amount of solute that can exist in the liquid at a given temperature in the amount already in solution, a decrease in melting time can be expected. The results of these tests contradict this assumption, but the increase of melting time can be explained on the basis of viscosity. The addition of alumina might have raised the viscosity to such an extent that even though the liquidus temperature had been depressed, the tendency for solution to take place more rapidly due to the greater solubility is nullified by the increased viscosity.

The relatively great increase in melting time accompanying the addition of two per cent alumina can be explained in at least two ways.

First, wollastonite is the final phase present in the base glass and is more readily dissolved in the liquid (glass) than silica would be; thus (s wollastonite—X_1) > (s tridymite—X_2) and the rate at which equilibrium (complete solution) would be attained would be greater if wollastonite were the final crystalline phase in a glass of the same viscosity. The final crystalline phase of the aluminous glasses was identified as tridymite and the rate at which these glasses reach equilibrium is slower than the base glass. Why wollastonite should be the final phase in the base glass and tridymite in the others is not clear, especially in view of Morey's[7] finding that the equilibrium phase is shifted toward wollastonite upon the addition of alumina.

A possible explanation for the presence of wollastonite is that during the preliminary fusion, the base glass was well on its way to equilibrium; and wollastonite being the primary phase, in this temperature range, was formed by the reaction of silica and the glass surrounding it to a great extent and only a small amount of free silica remained after this treatment, which, on further heating at a higher temperature, went into solution before the wollastonite. The viscous aluminous glass surrounding the silica grains in the other glasses reacted slowly with the silica and formed only a small amount of wollastonite and a large amount of the free silica remained. At the higher temperature, this wollastonite would go into solution rapidly leaving the silica as the final crystalline phase.

The second explanation of the decided increase in melting time is one of viscosity only, the nature of the final crystalline phases having no influence on the rate. Small additions of alumina raises the viscosity markedly at lower temperatures and further additions do not change the viscosity to the same extent as the first addition. Above 1250°C the melting time is very nearly a linear function of the alumina additions.

(*Concluded on page* 131)

FRANCIS C. FLINT

Chief Chemist of the Hazel-Atlas Glass Company, will lead the American Ceramic Society during the coming year.

WATER COOLING GLASS TANKS

THE water cooling of glass tanks is a subject of much interest to the practical glass man. In reading through the glass patents he sees designs and specifications for water cooled bridge walls, dog houses, throats, sidewalks, bottoms, corners and every other conceivable part of the furnace, including the crown. On the other hand, in his trips to various glass plants he sees very little water cooling actually being used. The question then arises whether this business of water cooling is incorrect or whether a valuable device is needlessly going to waste. The best answer to this question is a review of past experiences with water cooling.

In general there are two methods of water cooling. One, which is a simple procedure, is to spray water directly onto the outside block surface. The water that is not evaporated flows into a trough and is reused. The other method is where a metal pipe or box is placed in contact with the block. Cold water circulating through the pipe or box acts as the cooling medium.

The main disadvantages of the first method are as follows: Since tank blocks are made of unglazed clay, it is only natural to expect that they will absorb some of the water that is being sprayed upon them. In time the block will become soft and lose strength. If a small hole has been started, the force of the water spray may be sufficient to break off large fragments of the block at the point where the spray is being applied. If the joint between the block and the tuckstone is bad, there is the possibility of water getting into the glass and causing seedy and cordy glass.

Aside from these disadvantages, the economic side of this method is very important. In most cases water is expensive and in water cooling by the spray method very little of the water can be reclaimed for further use. As will be shown later in the consideration of water boxes or jackets, the use of pure water is a prime requisite. This is also true of spray cooling. Water containing a large amount of dissolved salts when sprayed on a hot block will evaporate and leave a deposit either on the blocks or in the return trough. If not removed from the blocks it acts as an insulator and the blocks become hot. If not removed from the trough, clogging will result. In both cases the cost of removing the deposit is important.

The spray method is a last resort in cases where a spot has worn through and a break has or soon will occur. Being a last resort method, the above disadvantage loses its importance when it is considered that its use often will gain several extra weeks run from a worn out tank.

In the case of water boxes or jackets on the sidewalls of a tank the main disadvantage from a practical point of view is that there is nearly always a poor contact between the wall of the cooler and the outside of the block. The air gap so formed acts as an insulator and the block becomes hotter at the points of poor contact and wears away faster than if the cooler were not present. One of the best methods of overcoming the poor contact difficulty is to fill in the space between the block and the cooler with clays. While this is not a sure method, as the clay on drying may crack and leave air spaces, it is better than spending time and effort designing a water tank to fit the block.

If the water used for cooling contains a large amount of sulphates and carbonates of calcium and magnesium, the formation of a large amount of scale in the water box is certain. Because of the difference in solubility of these salts in cold and hot water, they will be precipitated and become attached to the walls of the container in a more or less adherent deposit. Mud or sediment may also settle out in the jacket and form a deposit. The formation of scale decreases the cooling ability of the jacket and acts as an insulator causing the block to become hotter. The scale also causes the iron to bulge and burn out at the points where a thick deposit has formed.

Pure water is therefore an essential to the proper operation of water boxes. If a supply of pure water is not available, a water treating plant must be installed and its cost will often prevent small plants from making proper use of water cooling devices.

If the construction of the water jacket is such that steam pockets may be formed, the jacket becomes inefficient at the points where the steam pockets are located because they act as insulators and the iron may burn through in a short time. In a correctly designed water box the exit of the water from the cooler should be at the highest point and a constant circulation of the water maintained.

Other causes of water box failures are: air in the water which causes a chemical action of the iron and air to take place, with resultant pitting of the box; galvanic action and acidic action. While these causes may be overcome by the use of the newer corrosion resisting alloys, the first cost of the box is materially increased.

Whether or not water cooling lowers the temperature of the tank block is a much disputed question. In the case of spray cooling a decided lowering of the block temperature should occur, but the many disadvantages of this method prevents its recommendation except in cases of necessity. In the case of the water jacket, lowering of the block temperature should occur if good contact is established. If the contact is poor any cooling accomplished must depend upon the fact that the water jacket is a good absorber of radiant heat.

If the blocks are penetrated the glass will freeze against the water box and delay a shutdown. In many cases one or two blocks may go and the correct use of a water box will keep the tank running for many days before an actual shutdown of the tank is necessary.

It is when water jackets are used in this manner that exceptional care must be taken of the purity of the water, the design of the jacket and most important of all, the constancy of the water supply. If the water supply fails and some of the jackets in use are holding back frozen glass, it is only a matter of a few hours before the glass becomes reheated, the jackets let go and the tank is in the cellar.

It is the opinion of many practical men that water cooling in the early stages of the furnace run is needless and expensive but that it has its merits when the tank is on its last legs and production still has several weeks to go.

TESTING THE HARDNESS OF GLASSES

The interest of American glass technologists will be focussed on the hardness of glass at their annual meeting this month, when two papers treating this subject will be read. Of timely interest, therefore, the following translation by Dr. Samuel R. Scholes of papers recently appearing in Glass Technische Berichte. It is understood that our German contemporary will publish further papers dealing with the hardness of glass.—The Editor.

On the Hardness of Glass, by *M. Pirani and A. Fehse.*

THE question of the hardness of glasses can be considered from two points of view. First, as the derivation of a constant for the material, expressing its resistance against the attack of a body upon its surface, and aiming at reproducibility and a rating comparison with other substances. Second, the determination of a certain value to use in connection with methods of work, for example, turning, which would give some definite idea about the working hardness of the glass.

In the first case, it is necessary to define hardness and to give it a recognizable value represented by the Martin classification or the Brinell ball test. In the second case, there is one less degree of freedom. In the first case, it makes no difference whether the order of values for the investigated material by different processes remains the same or not. In the second case, the scale of hardness for the type of measurement chosen must give the same sequence of values that are obtained by the chosen method of working. This might be done, for example, with reference to the process of grinding.

This present paper attacks the problem of the working hardness of glasses, as it is presented in the process of turning, by a simple laboratory experiment which can be carried out rapidly with relatively small bodies of material. As a result, a series of values of "turning hardness" of glasses may be established. From the present point of view, this appears to be more interesting, because working glass in a turning lathe is beginning to have a great deal of importance in the art, since it has become possible by means of the Widia tools to work glass in much the same way as is customary with other materials, such as cast iron.

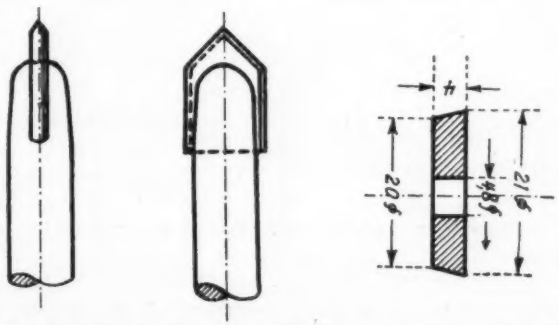
The first part of these experiments were carried out on the turning lathe with five glasses supplied by the Jena Glass Works. In order to have the same geometric relations, there was employed as a working tool a round, hard-metal plate 4 mm. thick, 21 mm. in its greater diameter, and 20 mm. in its lesser diameter. After each trial the disk was rotated into a new position, thus exposing a cutting edge of equal effectiveness in all the trials. A glass cylinder 47 mm. in diameter was turned off over a length of 110 mm. using a depth of cut of 0.5 mm. with a feed of 0.127 mm. As a measure for the workability of the glasses, the reciprocal value of the dulling of the working tool was taken. By dulling is understood the surface measurable under the microscope which is worn away from the working tool by the turning process.

Four series of trials showed that it was not possible to obtain a reliable sequence of values under the given working conditions. It became apparent that there were great differences in the workability. Although harder glasses gave definitely greater dulling—for example, the hardest, B K 1, seemed upon five trials to occupy the first position four times and the second place, once—the sequence on the whole varied as the experiments proceeded, with the glass specified. It appeared possible to get a reliable rating after a number of results were averaged, especially the results of experiments upon working with many pieces of the same sort as in mass production. As a laboratory experiment for the rapid estimation of working hardness, this method is obviously not recommended.

In the second series of experiments, a drill was used in a similar manner on the lathe. Here, in contrast to the turning experiments, a definite sequence in each series of experiments could be established with certainty. To measure the boring hardness, the penetration depth of a hard-metal drill, with a load of 10 kgs., rotating 700 r.p.m. was chosen. It became apparent that these values showed a limited variation (about 20 per cent), and that the sequence with tools of different strengths of attack remained the same. When this sequence is compared with the order obtained in the turning experiments, the agreement is very apparent, in spite of the variation in the turning results already given.

The relationship between the drilling experiments and the turning experiments, because of the wide variation in the latter, is not yet to be regarded as completely established. In spite of this fact we can conclude from the great similarity of the two working processes on bodies which form no coherent turnings, that such a relationship between the practical turning process and the laboratory drilling process exists, and that it is possible to sort out glasses according to their turning hardness without being obliged to make a lathe experiment each time.

It is clear that every other process of working would require another laboratory experiment; and that it by no means follows that the serial order of the glasses would remain the same for different kinds of working. For example, in the case under consideration it was established that glass K 9, which appears to be soft under drilling and turning, under grinding is essentially harder in relationship to the other glasses. According to a communication from Mr. Berger, it stands in the second place.



Left: hard metal lathe tool. Right: hard metal drill (scale, 2:1).

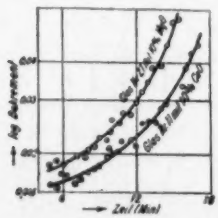
It appears certain that one can not carry over the laboratory processes which serve for estimating the working hardness of glasses to materials with other fundamental properties. The differences become all the greater, the more the formation of coherent turnings from ductile metals involved the cut and the vibration of the tool. This is obvious to a machinist, but will bear mention here since this communication is not for specialists in this type of work.

In order to give no false impressions to those who might apply the test methods, it is necessary to dispense with the word "hardness." The "hardness" of materials, whose definite susceptibility to attack is not yet determined, will certainly stand in some relationship to the "resistance of the material toward a special kind of working" here described. However, this relationship is not yet clear. On the other hand, the operator will not know much about "hardness," but will have a value which might be called the workability, as for instance, "ease of grinding" or "ease of drilling."

In general, since chemical effects also seem to play a part in the applicability of a tool, one can never bring the materials of different glasses into comparison with each other. A characteristic example of this is the working of hard resins with steel, which exerts a rather stronger attack upon the tool than does the working of definitely harder brass with steel. In glasses, this variable is missing, since there is no chemical influence on the metallic carbides by metallic oxides in the form in which they appear in glass.

Pendulum Hardness of Glasses, by *W. Schmidt and H. Elsner von Gronow.*

HARDNESS seems to be one of the properties of glasses which can be easily investigated, and in this investigation only a few definite precautions need be taken. It is difficult to make a satisfactory definition of hardness as we study it with the current processes. However, all of these methods can be assembled into a simple scheme which may be called the study of the tearing under a force attacking as nearly as possible at one point; that is to say, under a stress which is completely inhomogeneous, and therefore brings about the greatest general attack. By limiting the attack to a point, the reproducibility of this experiment is assured. This kind of destruction is much like the very common wear which bodies are required to undergo in every day life. The measurement can be made either through the force necessary for the abrasion or by measuring the abrasion either in linear dimensions (the scratch hardness of Martin), or in volume dimensions (grinding hardness), finally also through the work applied during abrasion.



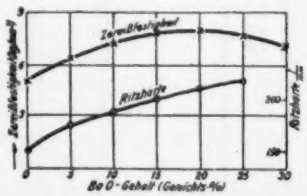


Fig. 1, Left: Logarithmic decrement of the pendulum swings in two series of experiments. Fig. 2, Right: Tensile strength and scratch-hardness of glasses with increase of Ba-O content. (After Gehlhoff and Thomas).

The pendulum test for hardness, as well as Shore hardness testing, works according to the last method. It was introduced into technology by Herbert, and also patented by him. Recently Russian researchers have published along this line.

A pendulum with a cutting edge swings over the test piece employed as a bed-plate. The work done in the abrasion of the bed-plate is obtained from the energy of the pendulum. The decrease in the amplitude of the swing gives, therefore, a measure for the work of abrasion. The mass of the pendulum consists of a symmetrically formed bow on whose ends two weights are fastened. The knife in the plane of symmetry is 2 mm. long, the radius of curvature of the knife, 0.5 mm. It consists of Widia metal contributed by the Osram Company. A sliding weight on a threaded spindle above the knife establishes the location of the center of gravity and accordingly the period of the swing. In these trials, the period was six seconds, the weight of the pendulum 1 kg. The test piece was cemented with a thin layer of resin to a heavy tripod, and could be adjusted to a level. The pendulum could be held at rest by a trigger. A representation of the stroke was obtained photographically on light-sensitive paper. To this end a mirror was attached to the pendulum. This arrangement was suitable for the evaluation, but any other simpler method could have been applied.

The pendulum thus passed over its bed-plate in swings whose amplitudes decreased. The decrease of these amplitudes depended upon the loss of energy of the pendulum, and upon this loss was predicated the work of abrasion on the test piece, the work of abrasion of the knife, and finally also the resistance of the air. We can eliminate the work of abrasion of the knife since this was made of the hardest possible material, very much harder than the test piece, which became possible by utilizing Widia. The resistance of the air is very small. Its influence could be accordingly still further discounted because the work of abrasion was made very much greater by using a heavy pendulum.

The theory of "dampened swings" is worked out on the supposition that the resistance is proportional to the amplitude at that moment. Hence is derived a type of swing in which the relationship of successive swings is constant or in which the difference of the logarithms of the amplitudes of successive swings is constant. (logarithmic decrement).

The analysis of the swing patterns in these experiments shows that here no simply damped vibrations are present, but that the logarithmic decrements increase with the time of continuation of the swinging process. The resistance can therefore not be proportional to the amplitude of swing, and the process approaches the other limit, where the resistance shows a constant value. This becomes quite apparent, when one recalls, that the knife exerts a "rubbing" on the plate. The result is, however, that the loss of amplitude depends not only upon the amplitude at the moment, but also upon the initial amplitude, (as the examples in Table I show), where the same glasses are chosen, with initial amplitudes of 100 mm. and 88 mm. (on the registering paper). We can thus estimate hardness only from the loss of amplitude at equal amplitude and equal initial amplitude.

Because of this inconstancy of the logarithmic decre-

Table I. Summary of Amplitudes in the Pendulum Hardness Testing of 5 Optical Glasses. (Vibration period 6 seconds).

Number of Swings		BK 1 mm		SK 6 mm	SF 2 mm		LF 3 mm			K 9 mm	
0	A_0	100	88	100	100	88	100	88	100	100	88
45	A_1	68,0	71,7	67,7	70,6	70,0	74,8	70,5	72,5	72,5	71,2
90	A_2	51,8	58,6	52,7	56,1	59,2	60,3	—	56,3	—	60,9
135	A_3	38,5	45,6	42,3	45,8	50,0	49,3	49,8	43,2	43,2	52,1

Table II. Amplitudes of Pendulum Swings After 6, 12 and 18 Minutes. The A_0 was in all cases 210 mm.

Glass No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Min.																												
6	0	123	116	138	162	128	142	156	114	132	144	156	150	147	156	160	157	32	58	105	100	98	130	142	151	134	136	135
12	0	54	50	76	97	64	81	106	48	68	87	107	101	97	110	118	106	0	0	35	30	26	52	89	100	70	72	72
18	0	8	9	28	45	20	32	64	8	21	51	65	61	56	(57)	(82)	64	0	0	5	0	0	13	50	52	24	22	24

Table III. Composition of the Glasses Investigated, in Weight Per Cent.

Glass No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Na_2O	18	18	18	18	18	18	18	18	18	18	18	18	17,5	15	12,5	10	—	18	18	18	18	18	5	—	18	18	18	18
SiO_2	82	77	72	67	57	72	67	62	57	77	72	67	60	60	60	60	60	78	74	70	67	62	60	60	77	77	72	79
BaO	—	5	10	15	25	—	—	—	—	—	—	—	20	20	20	20	20	—	—	—	—	—	—	—	—	—	—	—
PbO	—	—	—	—	—	10	15	20	25	—	—	—	—	—	—	—	—	—	—	—	—	—	20	20	—	—	—	—
Other Oxides	—	—	—	—	—	—	—	—	—	5	10	15	2,5	5	7,5	10	20	4	8	12	15	20	15	20	5	5	10	3
											CaO				K_2O					B_2O_3			K_2O	ZnO		MgO	Al_2O_3

ment (Fig. 1), it does not seem decisive to reckon the logarithmic diminution as a measure of the hardness; we have therefore introduced only the amplitude in our example. In Table II the amplitude is given after a definite number of minutes, in Table I the amplitude after a definite number of swings. Since the period of vibration (swing) is essentially dependent upon the damping, the two estimates are comparable without further calculation.

In general, the measurements of pendulum hardness are easily reproducible, as K 9 in Table I shows. Nevertheless, from the same table it may be inferred, that the ranking of the specimens as to hardness is not the same, for any chosen initial amplitude. This fact requires clarification, which cannot be attempted here because the test pieces were different for the 100 mm. and 88 mm. initial amplitudes, although made of the same kind of optical glass. Attention must be called to the influence upon hardness of substances active at the surface. One may conjecture that the alkaline solution, to be expected on the surface of glass in damp air, albeit no more than a greasy film, has an essential influence on the pendulum hardness. Standards must be established, accordingly, for the handling and storage of the glass surface.

Because of the influence of contamination of the surface, it would seem desirable to work for a greater abrasion, that is, with a heavier pendulum.

Two series of experiments were made. One was aimed to decide whether the pendulum hardness could give a useful measure for the resistivity of a glass. A second series employed 28 melts systematically varied, which had already been investigated by other authors using other procedures as to their physical-mechanical properties. The great majority of these melts are based upon a parent glass containing 18 per cent Na_2O and 82 per cent SiO_2, with systematic substitution of the silica by other oxides. The composition of these glasses is presented in Table III.

The test pieces were glass plates 3 mm. thick cemented to a metallic bed plate. The plates were polished on pitch by Parisian Red. Accordingly they possessed no fire polish. It is recognized that the scratch hardness of fire-polished surfaces differs little, while the same glasses mechanically polished show distinct differences in scratch hardness.

The results on pendulum hardness are compared with strength properties found by Gehlhoff and Thomas. Figure 2 shows the relationship between tensile strength, scratch hardness, and BaO content, according to those authors. In the present experiments, the authors remark that the pendulum hardness follows the same course, and a direct relationship is thus indicated between tensile strength, scratch hardness and pendulum hardness.[1] These results were also established on the other glasses.

The pendulum hardness of the lead glasses increases up to 20 per cent PbO. The addition of lime brings about a continued increase in hardness. When the alkalis are varied and the BaO content remains constant at 20 per cent, the hardness reaches a maximum value at 10 per cent K_2O. These results could not be compared with those of Gehlhoff and Thomas, who used only 15 per cent total alkali. When B_2O_3 is substituted for silica, the hardness increases up to the 12 per cent addition, and then falls off again. The results on ZnO, MgO, and Al_2O_3 are self explanatory.

[1]This is all somewhat confusing, since it is obvious that the residual amplitude or length of swing of the pendulum shows a relatively steady increase except for Glass No. 3, throughout the Barium series. This would seem to indicate increasing softness, rather than increasing hardness.—Translator's Note.

FEBRUARY PLATE GLASS PRODUCTION

The total production of polished plate glass by member companies of the Plate Glass Manufacturers in February was 13,856,937 square feet as compared to 17,275,632 square feet in January and 13,723,151 square feet produced in February, 1935.

THE 200-INCH DISK TRAVELS

Photos by John R. Hostetter, Corning Glass Works.

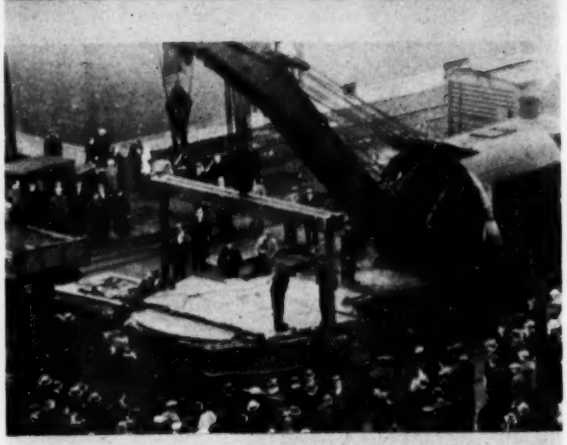
THE photographs on this and the following page, illustrate the tremendous task of moving the 200-inch disk from the testing house of the Corning Glass Works on the banks of the Chenung River to the tracks of the New York Central Railroad. Tight passages had to be negotiated and part of a railroad trestle within the plant property had to be removed to facilitate passage of the disk and its giant crate, which alone weighed 15 tons. Traveling at the speed of a quarter of a mile in 30 hours, the 35 ton disk and crate reached the special well-hole tyne railroad car which will carry it to Pasadena. This first step in the long journey is shown here. Note that a special truck trailer of the type used to transport steam rollers from city to city was utilized.

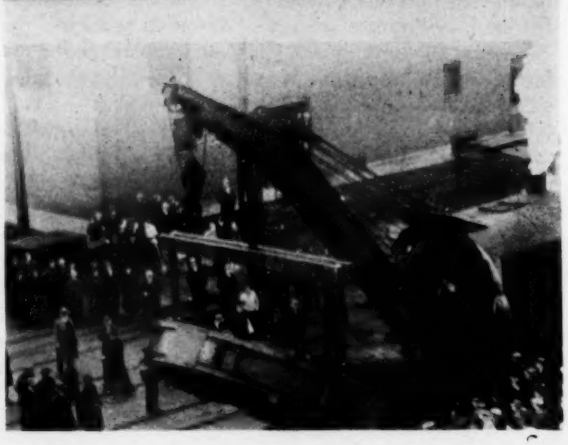
When the disk rests vertically in the railroad car, it will have a maximum height above the rails of 17 feet, 6 7/16 inches. The lowest part of the undercarriage will be 5½ inches above the rails. New York Central officials advised that the minimum clearance between the top of the steel crate and lowest overhead obstruction would be three inches and this would occur only in the case of a bridge at Buffalo. The wheels of the special car are made of wrought steel and are 26 inches in diameter instead of the 33 inches which is standard for freight cars.

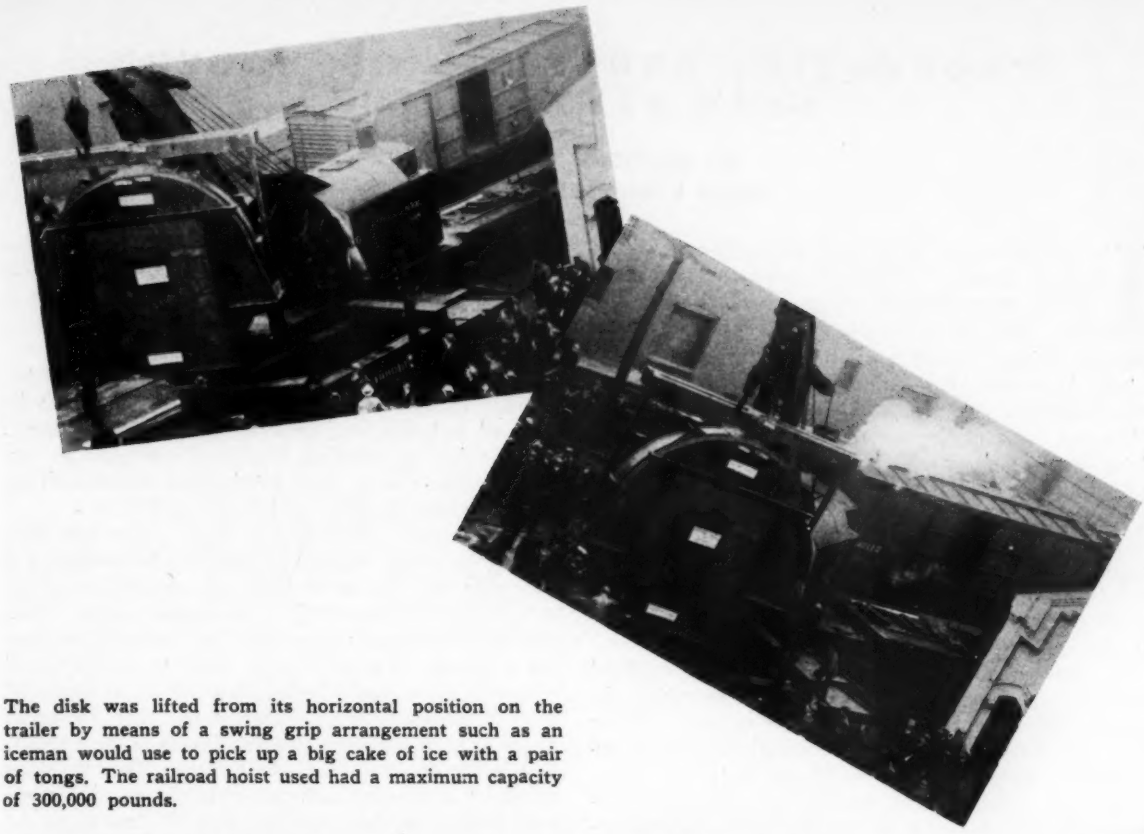
The train will travel at a speed of not more than 25 miles an hour and only at night. The disk will go from Corning, by way of Lyons, N. Y., to St. Louis and Kansas City, arriving in Pasadena, where it will be unloaded. Three tons of steel rails will be welded to the top of the car on each side, and will serve to lower the center of gravity about three inches. Instruments will be attached to record shocks.

And when the disk finally does arrive in Pasadena in its sheet steel housing, then the real fun will begin when it must be transported up Mt. Wilson to the observatory. Just one of the details of this mountain climb is a special road, now under construction.

A last minute news flash from Corning reveals that the floods in New York state have not harmed the disk, although the Corning plant has had considerable trouble with its source of power shut off. The room where the disk was annealed was flooded, but fortunately the railroad tracks are away from the raging waters. The journey to California will be delayed until all roadbeds are carefully inspected to make sure that the nation-wide floods have not harmed the mapped out route.







The disk was lifted from its horizontal position on the trailer by means of a swing grip arrangement such as an iceman would use to pick up a big cake of ice with a pair of tongs. The railroad hoist used had a maximum capacity of 300,000 pounds.

PROPERTIES AND TESTS OF MODERN CLAY FLUX BLOCKS

By GEORGE A. LOOMIS
Ohio Valley Clay Company

IN AN article by W. L. Fabianic in The GLASS INDUSTRY, January, 1936, the improvements made and desired in glasshouse refractories were very ably discussed. With regard to clay flux blocks, it was stated that much improvement has been made by the manufacturers in recent years but that these blocks are still unsatisfactory. This is undoubtedly true in general. However, some of the more progressive manufacturers have closely approached, if they have not already attained, the desired goal of producing a flux block to give very satisfactory service.

The modern type of clay flux block, which was made necessary by the present higher melting temperatures and the increased rate of production in tank furnaces, is quite different from the now obsolete porous, comparatively coarse grained, soft burned block.

Formerly a porosity of 25 per cent was considered satisfactory, but for best resistance to corrosion the modern clay flux block must have a porosity of less than 20 per cent. In one or two cases this has been successfully reduced to as low as 14 per cent.

In order to bring about the desired resistance to corrosion by this reduction in porosity it has been necessary to sacrifice somewhat on resistance to heat shock since the two properties are incompatible. For this reason a little more time is usually allowed to heat up the tank built with this modern type of block than was required for the porous, coarse-grained block which failed because of a lack of resistance to corrosion. With a little extra care in heating up the tank, some very dense blocks having a porosity as low as 14 per cent have been found to cause no trouble from cracking or spalling.

While some tank block manufacturers may have sacrificed somewhat on the refractoriness of their flux blocks in order to lower the porosity and attain better resistance to corrosion, the best practice has been to attain the desired low porosity, without any decrease in refractoriness, by firing the blocks to much higher temperatures than formerly.

By being fired at or above glass melting temperatures, such clay flux blocks have little or no tendency to shrink in service. By maintaining tight joints in this way there is less tendency for more rapid corrosion at the joints than elsewhere.

The determination of porosity, shrinkage, or permanent expansion on reheating, pyrometric cone equivalent, chemical and petrographic analyses, and some modified form of heat shock test are all desirable and usually advisable in testing flux blocks. However, none of these tests can be substituted for the direct determination of resistance to corrosion. With the exception of refractoriness all other tests are of minor importance compared with corrosion resistance.

In the writer's opinion, the only reliable laboratory test of corrosion of tank blocks is in a miniature tank employing a commercial glass batch or one modified somewhat to increase its corrosive action. In cases where the test blocks do not differ greatly in resistance to corrosion, the test must be run continuously for several weeks to obtain reliable results. Tests of a day or two in crucibles or otherwise are of little value except in eliminating very poorly resistant materials.

The miniature glass tank used by the writer is illustrated. This furnace is a duplicate of one which he designed and first used in 1919 in another laboratory. Its reliability in showing results of resistance to corrosion comparable to those obtained in service with the same materials has been well demonstrated.

This furnace differs mainly from other miniature glass tanks in that the test blocks form the sidewalls of a circular tank which revolves continuously during the test. The turntable carrying the circular bottom block and radial test blocks is revolved by a suitable mechanism at the rate of about 8 r.p.m. The furnace is heated by means of a single burner inserted in a tangential hole in the stationary superstructure. The burner is placed in such a manner that its blast is in the opposite direction to the rotation of the furnace. Thus the glass movement is retarded with respect to the circular movement of the test blocks and the flow of glass along the sidewalls of a commercial tank is simulated. Due to the tangential burner and the rotation of the tank all of the test blocks receive the same treatment throughout the test.

The burner used in the present furnace is of the premix gas-air type. Fuel oil and compressed air were used successfully in the previous installation mentioned.

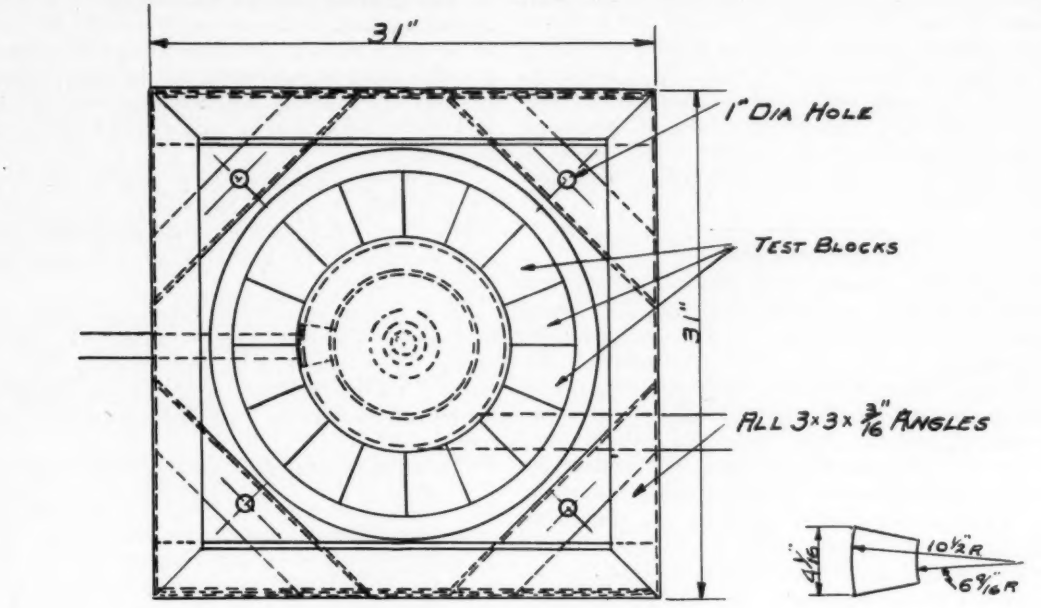
In making a test, duplicate blocks of each material to be tested are placed side by side in the circle. There is thus room for eight different materials in each test. By using duplicate blocks placed together, the resistance of the material to corrosion at the joints may be determined.

As a standard of comparison, a pair of blocks from a large lot of identical material is always included as it is not always possible to maintain exactly the same conditions in each test. With such a standard of reference in each test, comparisons may be more readily made between materials tested at different times.

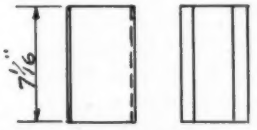
In making the test, the temperature is brought up to a maximum (about 2600° F. with the premix gas burner) in about 24 hours. At this time the glass batch is filled in until within 1½" of the top of the test blocks when melted. The glass is ladled out and replaced two or three times a week.

The glass employed is usually a commercial raw batch. When this is used the test is continued for about four weeks. A special highly corrosive glass cullet has also been used which has been found to give the same results in about one-third of the time as obtained with one type of commercial soda lime glass. Its composition is as follows: Potash 40, Lime 40, Sand 20, Nitre 2. This special batch is completely melted and ladled into water before using in the test.

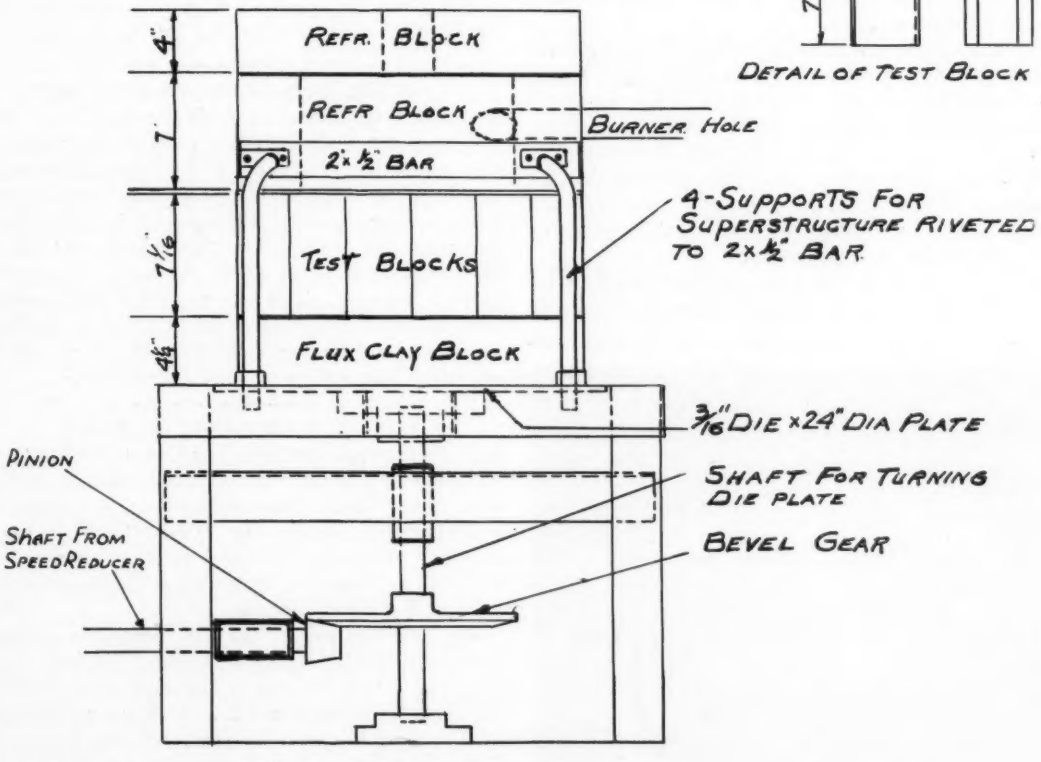
While this special cullet has been found to give like results in one-third of the time required for one type of commercial glass, it is not recommended for general use in corrosion tests. In general more reliable results will be obtained by using the commercial glass to be resisted in service and allowing the extra time required to properly differentiate between the materials being tested.



PLAN VIEW OF CIRCLE BRICK SUPERSTRUCTURE REMOVED



DETAIL OF TEST BLOCK



SIDE ELEVATION

Sketch of the revolving test furnace.

PLANT TRIPS AT THE A. C. S.

One of the features of the American Ceramic Society Convention at Columbus, March 29 to April 4, are plant visits on Friday, April 3. In the morning, the following plants may be visited: Ebco Manufacturing Co., manufacturers of cast iron and steel enameled ware; Owens-Illinois Glass Co., whose Columbus plant is devoted to making plain and fancy milk bottles; D. L. Auld Co., makers of enameled automobile radiator name plates, etc. The afternoon trips are primarily of interest to members of the white wares and art division and the enamel division. A golf tournament will also be held Friday afternoon.

A CORRECTION

An item appeared in the March GLASS INDUSTRY that contained a serious typographical error which we hasten to correct. Reference is made to page 80, under the title Nepheline Syenite, where attention is called to the use of nepheline syenite as a batch constituent. In reporting the analysis, the soda content was given as 0.91 per cent, and this should have been 9.91 per cent.

The editor's attention was called to this mistake by Charles L. Cruikshank, head of the Ceramic Department, Great Lakes Foundry Sand Co., Detroit. In addition to correcting the error in the analysis, Mr. Cruikshank gave other interesting data. We quote from his letter:

"This new rock in concentrate form has certain characteristics which will make it very attractive to the ceramist not only from the standpoint of chemical analysis, but also on account of the size and uniformity of the deposit. The quarry of Canadian Nepheline, Ltd., is located at Blue Mountain in Methuen Township near Peterboro, Ontario.

"The huge Nepheline Syenite body at Blue Mountain is an igneous rock which is intrusive into a surrounding mass of amphibolite schist, except for a section along the southeastern margin, where it is in contact with granite, which is a prominent outcrop in the area, known locally as the Methuen granite batholith. It is believed that the intrusion of the deposit into the amphibolite accounts for the exceptional freedom of deleterious constituents and its uniformity of composition.

"Other Nepheline Syenite rock masses have been located in various parts of Canada, but these are invariably intrusive into limestone beds and the assimilation of the limestone during the intrusive process has caused them to contain varying percentages of lime, thus rendering them unfit for commercial use.

"The grinding and concentration plant of Canadian Nepheline, Ltd., is located at Lakefield, Ont., and is, at the present time, completely equipped to produce a granular low iron concentrate for the glass industry. A modern high intensity induction type magnetic separation unit is being used to remove iron bearing minerals from the rock.

"One of the features of the processing mill is a complete chemical control laboratory where continuous analyses are being made of crude and finished product in order to insure the user of a source of uniformly low iron raw material.

"It is further proposed to install ball mills in order to further reduce the granular product to minus 200 mesh. These units will be installed early this year, as research work now being carried on has indicated that the pulverized material has definite advantages in many ceramic bodies.

"The chemical analysis of the concentrate is as follows:

Silica	59.43
Alumina	24.52
Iron Oxide	.06
Titania	.01
Phosphorous	.02
Lime	.27
Magnesia	.02
Soda	9.91
Potash	5.10
Loss on ignition	.44
Fusion	1210 C.

"The principal advantages of the product to the glass industry are the unusually high percentage of Al_2O_3 as compared to feldspars and the low iron content."

BALL BROTHERS TO ENLARGE

A report from Okmulgee, Okla., credited to C. H. Inglish, manager of the Ball Brothers fruit jar plant in that city, states that production will be greatly increased by certain plant enlargements. The present capacity of the plant is approximately 900 gross of fruit jars per day, and according to the report, the enlargement will mean the employment of 25 or 30 men more to operate the plant at capacity. This will mean the employment of a total of 200 men. Said to be included in the enlargements are a fifth jar making machine, an additional annealing lehr and another air compressor.

A glass block building doubled sales for a dairy.

C. B. ZABRISKIE IS DEAD

It is with great regret that The GLASS INDUSTRY records the death of Christian Brevoort Zabriskie, retired president of the Pacific Coast Borax Co. In addition to his achievement in making "the 20 mule team" famous, Mr. Zabriskie enjoyed a wide and varied existence, starting from his distinguished beginning as the first white child born in Wyoming Territory.

Mr. Zabriskie was at one time treasurer of the U. S. Borax Co., president of the National Sulphur Co., vice-president of the Tonopah & Tidewater Railroad Co. and the Death Valley Railroad Co. Among his club memberships were the Union League, National Arts and the Bohemian Club of New York. His collection of silverware and relics of the Far West was probably the finest in the country.

NOTES ON EUROPEAN GLASS INDUSTRIES IN 1935

By EDWARD J. DETGEN

Specialties Division, Bureau of Foreign and Domestic Commerce

GERMANY[1]

ACCORDING to the German Business Research Institute, there was a distinct improvement in the activity of the German glass industry during 1935. While final production figures are not yet available for the whole year, it is stated that the rate of activity in the flat glass industry towards the end of the year 1935 was 10 per cent higher than during the corresponding period in 1934. The index of industrial activity, based on the number of man-hours, climbed during the eight months from January to October, 1935, a full 15 per cent. As gauged by the consumption of coal by the glass industry, the activity was 13 per cent higher during the first nine months of 1935 than for the like period of 1934.

Owing to the practical absence of winter, building activities have continued up to the middle of January, causing an unusual demand for constructional glass for this time of the year. The great stimulating factor to the German glass industry was the promotion of building and construction work by the Reich Government, both directly, through an unusually large construction of public buildings and by encouragement lent to private and municipal enterprise through extension of lavish mortgage credits with Government guarantee.

In addition to a better showing in domestic sales, the German glass industry has also succeeded in expanding quite appreciably its export sales. Foreign trade statistics for the first eleven months of 1935 showed an increase in glass exports 14 per cent in value and 17 per cent in volume over the corresponding figures for 1934.

The flat glass finishing industry of Germany consists of several groups with great divergency of interests. Besides a small group of manufacturers producing their own rough glass, are a great many commission cutting and decorating plants and still more one-man shops. Owing to the activities of these small units willing to accept prices far below those derived from rational cost calculation, prices have been depressed to the point where plants organized on a commercial basis cannot derive any profits. To aggravate the situation still further, numerous glass dealers have adopted the practice of giving rough cast glass to commission shops and individual artisans to be finished to the order of the dealer.

A cartel of the flat glass finishing industry was organized sometime ago and attempted to bring order and cooperation into this division but its activity was ineffectual due to about 30 establishments refusing to join the cartel or obey its rules. After prolonged negotiations which brought no positive results, the glass cartel announced a stoppage of rough glass supply to the recalcitrant outsiders. As the manufacturers of rough glass are all members of the cartel, the non-delivery of raw material to the outsiders is expected to be enforced completely.

The recent step of the cartel is regarded as the beginning of a complete eradication of commission finishing. Official declarations to that effect are on record, not only on the part of the cartel but also of the German ministry of national economy which takes the stand that in the national-socialistic state every industrial division must stay within its definite scope of activity. In particular, the finishing of glass in connection with glass trade is regarded as illegitimate competition.

The situation of the German bottle glass industry improved greatly during 1935. Not only was the activity for the entire year higher than in 1934 but, in contrast to all previous experiences, the winter months caused no retardation in the flow of orders. Thus manufacturing activity could be continued at practically the same rate as during the summer and fall. Increased demand was noted for beer and mineral water bottles. Liquor and wine bottles were also in greater demand, the latter due to the "Patenwein" movement promoted by both official and commercial circles. This movement consisted in each important city or town playing "godmother" to a certain wine-producing district the citizens being induced to partake freely of the sponsored beverage which was offered in all restaurants and saloons at moderate prices.

The average increase in sales of bottles was 35 to 40 per cent over 1934. Even at that the production capacity of the works was only utilized to about 25 per cent. This is said to be due to the great surplus capacity brought about by excessive expansion of the industry in the past. Loss of export trade added to the difficulties of this industry.

A new German law of weights and measures which will enter into force on April 1, 1936, provides for the elimination of all gauging requirements (with the exception of foreign products traded in Germany in containers of the country of origin) and for the introduction of a standardized bottle (Normel Flasche). The comment issued by the Reich Ministry of Economic Affairs says that up till now no uniform order whatsoever obtained in the utilization of bottles for the sale of wines, beer, alcohol, etc. While before the war certain sizes were customary in the trade, exceptions have since become the rule. The so-called three-fourth liter wine bottle which prior to the war contained as a rule 0.73 liter has gradually become smaller; in fact 0.68 liter bottles are very frequent and even bottles of 0.60 and 0.58 liter content have been ascertained. This state of affairs is, the *Deutsche Weinzeitung* writes, a severe handicap to the trade becouse dishonest elements take advantage of the loose law by using bottles made of thick glass with hollowed bottoms. They allow the fixing of lower prices whereby sales can be increased to the detriment of the legitimate trade. The marking of the bottles with gauge-lines, obligatory in the case of beer and wine glasses, is impracticable as it would increase expenses. The only possible way open for fixing by law the volume of the bottle remains therefore the introduction of the standard sized bottle. As, in view of the large stock of full and empty bottles, the immediate all-round introduction of the standard bottle

[1] American Consulate, Frankfort-on-Main

would cause heavy losses to the trade, a transitory period of some length will have to be granted during which the old bottles will gradually disappear from the trade. Paragraph 52 of the law therefore provides that in the future bottles of a fixed volume may be produced only. As there exist only from 30 to 40 bottle factories in Germany the control will be comparatively easy.

Bottles for export will be exempt from the law in order to satisfy the particular requirements of the foreign customer. However, empty bottles imported from abroad and filled for trading purposes in Germany shall also be subject to the new law. The new law will not apply to imported filled bottles and imported empty bottles to be filled in Germany for export.

It should be emphasized, the *Wein-Zeitung* goes on to say, that paragraph 59 of the law empowers the Minister for Economic Affairs to modify or amend the provisions of paragraphs 54 and 55 by which the future standard bottle will be defined. In fact, no agreement seems so far to have been reached in this respect but the trade in general advocates the adoption of a bottle of 0.70 liter standard net content.

A number of German flat glass concerns including the Deutsche Tafelglas A.G. of Furth, Rheinische Ziehglas A.G. of Porz and Vopelius and Wentzelsche Glashutten founded early in 1935 a joint export organization, the Deutsche Fensterglas Ausfuhr A.G. with headquarters at Frankfort-on-Main. The Rheinische Ziehglas A.G. reports in its annual statement that a substantial advance has been realized in export sales which is attributable directly to the efforts of the newly founded export syndicate. However, these export gains have been largely due to lower prices and have not been a full success from the standpoint of financial returns. Nevertheless, the Rheinische Ziehglas A.G. could close the year 1935 with a moderate profit after a loss of 900,000 marks sustained in 1934.

A glass engineer from Prague, Czechoslovakia, presented at a recent glass convention in Berlin an interesting summary of problems confronting the research in the province of structural glass. The lecturer pointed out that a new kind of glass had been brought out which offers good heat and sound insulation, intercepts glaring light, and disperses the rays of light uniformly throughout the room. He suggested further that zenith light should be utilized by means of appropriate mirrors.

FRANCE[2]

DESPITE a concerted effort on the part of French glass manufacturers to improve conditions in the industry, sales during the past year continued to decline, with exports in particular reaching a new low level. The outlook for the immediate future is likewise far from encouraging, as in all probability any amelioration of the present situation must wait upon an improvement in general economic conditions and upon the intervention of a strong and stable government disposed to initiate and enforce measures for industrial recovery.

Imports of glass into France during 1935 showed a marked decrease in value and a slighter decrease in weight, a discrepancy due to the fact that foreign manufacturers have preferred to sacrifice profits and undersell their French competitors rather than lose their foothold in the French market. Thus, imports of mirrors into France during 1935 were 15 per cent below the 1934 figure in weight, and 20 per cent less in value, while glass and crystal ware, with a decrease of only 2 per cent in weight, showed an 18 per cent decline in value.

Export of mirrors in 1935 dropped 5 per cent in weight and those of glass and crystal ware 38 per cent as compared to 1934. The total value of such exports in 1935 was 42,554,000 francs, or one-eighth of the value of exports in 1929, and marked a decline unprecedented in recent years. With the development of glass manufacture in foreign countries and the consequent stringency of tariff and other protective measures, there seems little likelihood that the export trade will regain its former level. French manufacturers, therefore, will be forced to depend increasingly on the domestic market which, it is pointed out, can only be made profitable when government taxes are reduced to a point that will enable such manufacturers to offer prices as attractive as those quoted by their foreign competitors.

Indicative of the unfavorable conditions prevailing in the industry is the decrease in the number of glass factories in operation in recent years. In 1928-1929, such factories in France totalled 226 and employed 63,500 workmen, while in 1935 the total number of factories was 157 and that of workmen, 38,500.

BELGIUM[3]

ALTHOUGH the recovery in the glass industry during the year under review has not been reflected in the same degree as in some other industries, there have been developments in some branches of the trade that were encouraging.

In the window glass industry, there continued to exist the disturbing factor of one plant working independently of the Window Glass Producers' Union, which precluded the possibility of establishing a profitable sales program, as the outside plant would not adhere to a fixed price schedule. A second independent plant began production in November, and the Government intervened in recent negotiations between the Union and the two independent plants in an effort to effect an agreement on output and prices, but no agreement was reached, and other plants are planning to reopen after the installation of new machinery, which gives cause for apprehension as to future prices.

During the first months of the year, the production of the window glass plants was kept far below capacity and prices could not be raised on account of competition from the outside plant. However, the industry succeeded in increasing exports, but only through heavy price cutting. After the devaluation, the local market improved considerably, and pressing orders were booked to replenish dealers' stocks and to satisfy the demand of the building trade.

Throughout the year, the Window Glass Producers' Union was able to keep only four tanks working, while the outside plant was working at full capacity. Stocks were gradually reduced, but no inducement to increase production was registered.

The plate glass industry, which is strongly organized,

(*Concluded on page* 136)

[2] Asst. Trade Commissioner Earle C. Taylor, Paris.

[3] Commercial Attache, T. L. Hughes, Brussels.

SANDWICH GLASS

By ALEXANDER SILVERMAN[1]

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Article I on crystal batches appeared in The GLASS INDUSTRY *for February and article II on opal and alabaster glass in March. The present article will cover the red and pink glasses found in the batch records of William E. Kern and George L. Fessenden, to whom reference has been made in the earlier articles. So that batches of a related nature may be discussed together, the letter "K" preceding the number will indicate Kern, and "F" will indicate Fessenden. The Roman numerals after the Fessenden batches indicate Part I and Part II, respectively.—The Editor.*

GOLD COLORS

GOLD was first used to color glass in colloidal form in Purple of Cassius, where it was held on the surface of hydrated stannic oxide. The first gold ruby glass is attributed to Johann Kunckel (Germany, 1677).[2] Neri[3] had already dissolved gold in aqua regia for this purpose at the close of the Sixteenth Century in Italy, so it is doubtful whether Kunckel was the discoverer of gold ruby. In modern practice auric chloride or the trichloride of gold is usually sprinkled on a small amount of sand or a small portion of batch and allowed to dry or react as the case may be. This color-bearing portion is then added to the main batch and mixed with it. At the temperature of the melt, a glass is produced which appears yellow on gathering and cooling.

According to Bancroft[4], the gold may be in true solution or in particles so small as to have little color effect on a beam of light. It is converted to various shades of pink, red, purple, or blue according to the degree of reheating. The yellow glass is usually made into small gobs about an inch in diameter and six or seven inches long. The cold gobs are then broken up, and skilled workmen attach small pieces to a crystal or opal gather on a pipe. By reheating, the portion of the cold gob melts and is then skillfully distributed over the crystal or opal core. The color obtained is due to particles of colloidal dimensions.[5] It is claimed that the color which develops on heat treatment is dependent not only on particle size, but on particle shape.[6] One tenth of one per cent of gold or less will color glass, the facility of color production depending on the composition of the glass. Lead-, tin-, and barium-bearing glasses require less gold than lime glass. It is further claimed that increasing stannic oxide enhances the uniformity of red color and minimizes the tendency toward blue color formation with brown clouds of precipitated gold.[7]

Few modern manufacturers possess more than a single formula for making gold ruby glass. The breadth of knowledge possessed by the glass makers in the Sandwich factory is again in evidence when one considers the number and variety of gold ruby batches which were available. These will be discussed individually wherever interpretation is possible.

[1] Contribution No. 312 from the Department of Chemistry, University of Pittsburgh.

K 24. John Hopkins Ruby Glass:

Sand	238 lb.
Lead	152 lb.
Pearl ash	67 lb.
Salt Petre	28 lb.
Borax	21 lb.
White ox. antimony	1 lb.
Oxide tin	12 oz.
Gold	3 oz. 1 pwt.

"Mix this thoroughly turning two or three times. Put the tin, antimony and manganese on the sand, then the lead, ash, borax, and saltpeter. After you have done this make it hollow in the center from end to end. Pour the Gold in the middle of the batch and turn again. Take 8 oz. of nitric acid, 16 oz. of muriatic acid, 16 oz. of distilled water, mix them together, mix in with the batch. Turn again well. Fill the pot full. Melt until it is in a good boil. Dip it into a clean kettle for dragade. Then fill the pot and top. Use batch enough to make the pot full. Melt till plain, which may be 24 hours after topping."

The title of this batch seems to indicate that it was developed at Johns Hopkins University. Lead, as suggested in the earlier articles in this series, is red lead. White oxide of antimony is the trioxide. The oxide of tin is probably stannic oxide, though stannous or gray oxide is employed in more modern practice. Fessenden's notes, "oxide of tin is used in enamels and in combination with gold in making ruby; it should be very white and fine," justify the assumption that stannic oxide was employed.

It is interesting to note that after the gold was dissolved in aqua regia the solution was poured into a depression in the middle of the batch. The instructions for dissolving the gold are somewhat amusing. "Make a bottle that will hold a quart not too thin. Take 8 oz. of nitric acid, 16 oz. of muriatic acid, mix them in a bottle, put the Gold in little at a time. Put the bottle on some sand and it will soon dissolve."

As was often the practice among earlier glass makers, the melt was brought to a boil and then run into water in an iron kettle, forming dragade, now known as frit. This was returned to the pot and melted with more batch.

It was customary among the earlier glass makers to let the pot charge melt down and then introduce more batch. This was called "topping." It insures a larger amount of glass for working and in the case of colored glasses often improves the color. Some modern manufacturers still follow this plan.

A group of workers taken in front of the eight pot furnace in the Sandwich plant. A. E. Saunders, Magistrate of Millville, N. J., who supplied the photograph, is seated in the foreground.

The following crystal batches seem to indicate that Sandwich practice differed somewhat at times from that suggested by the author in the introduction to this article.

K 29-A. F. L. Shirley's Last Batch for Coating Ruby:

Sand	1200 lb.
Lead	700 lb.
Ash	400 lb.
Salt Petre	120 lb.
Arsenic	1 lb.
Manganese	1½ lb.

K 29-B:

Sand	1200 lb.
Lead	600 lb.
Refined ash	420 lb.
Bone	6 lb.
Arsenic	1 oz.
Nitre	90 lb.
Manganese	15 gr.

Note that Shirley's batches are intended for coating ruby. There is a possibility that a small gather of ruby was made on the pipe first, blown slightly, allowed to set, and then introduced into crystal for a second gather or coat. The terms "cased ruby" and "flashed ruby" have both been used in the industry. Cased refers to the ruby on the interior, and flashed to ruby on the exterior of the crystal.

K 30-A. Shirley's Receipt for Flint for Coating Ruby:

Sand	1200 lb.	1200 lb.
Lead	625 lb.	700 lb.
Pearl ash	360 lb.	360 lb.
Soda	120 lb.	60 lb.
Salt Petre	40 lb.	80. lb
Borax	2 lb.	2¼ lb.
Arsenic	1½ lb.	1½ lb.
Manganese	12 oz.	12 oz.

K 30-B. James D. Lloyd's Ruby:

Sand	32 lb.
Lead	32 lb.
Salt Petre	16 lb
Gold	1 oz.
White oxide of antimony	2 oz.
Manganese	1 oz.

K 30-A was evidently intended for working with K 30-B. In the latter, no instructions are given for the preparation or addition of the gold solution. No tin compound or reducing agent is present in appreciable quantity; in fact the batch which is rich in red lead contains considerable saltpeter, which is an oxidizing agent. A small amount of manganese is also present. This gives a purple tone to the ruby when used.

It is questionable whether reducing agents are essential in a gold ruby glass. As already stated, Bancroft has intimated that the gold might be present in true solution as a molecular compound or in particles so small that no appreciable color is produced in the initial melt. Gold compounds are unstable and readily dissociate on heating. Therefore, the gold particles of a size determined by heat treatment should form anyhow.

K 32. Fessenden's Pot Ruby:

Sand	300 lb.
Lead	200 lb.
Potash	80 lb.
Salt Petre	40 lb.
Regulus antimony	5 lb.
White oxide of tin	2 lb.
White oxide of antimony	2 lb.
Manganese	2 lb.
Red oxide of iron	6 oz.
Gold in solution	3 oz.

"Remark: to the above batch add 10 oz. of green oxide of nickle. Will give a purple ruby very rich."

This batch, presumably Fessenden's, has no counterpart in Fessenden's records. Regulus antimony is the metal. It serves as a reducing agent, but a large amount of niter is also present which counteracts its effect. Red oxide of iron is mentioned for the first time. This is frequently used in gold ruby batches. It is interesting to note that nickel oxide, which produces a purplish brown color, is used to enhance the gold color. Whether "pot ruby" means that the color was red when the glass was gathered is a question which the author can not answer.

K 37. Shirley's Best Ball Ruby:

Sand	255 lb.
Red lead	255 lb.
Potash	24 lb.
Nitre	102 lb.
Manganese	24 oz.
White oxide of antimony	15 oz.

"Note: Prepared Gold 22 pennyweights. Mix into Sand This glass cannot be improved upon. Fill batch into small twin pots. Let cook 18 hours. Then dragade. Fill again and then top. Let cook 24 hours; then it is ready to work."

This batch contains an unusual amount of niter and enough manganese (dioxide) to influence the color appreciably. Why the batch should be filled into twin pots is uncertain. It apparently produced a very fine color.

F 12-I. Ruby:

Sand	300 lb.
White lead	200 lb.
Refined pearlashes	80 lb.
Nitrate of potass	10 lb.
Regulus of antimony	5 lb.
Oxide of antimony	2 lb.
Oxide of tin	2 lb.
Manganese	2 lb.
Red oxide of iron	6 oz.
Gold	4 oz.

"The gold to be used in solution dissolve it in Nitro Muriatic Acid otherwise called Aqua Regia, this consists of four parts Muriatic and one part Nitric Acid. You may if you like vary the proportions. I have as often used two parts Muriatic and one part Nitric. Dissolve the Gold in boiling acid, let it cool and add a little water, and mix your solution carefully with your white lead, and then mix with the other ingredients.

"White lead is the carbonate of lead and I prefer it to Minium for making Ruby. The French name for it is 'ceruse' or 'blanc de ceruse.'"

Aqua regia is prepared by mixing three parts of hydrochloric or muriatic acid with one part of nitric. Observe the variations in the proportions used by Fessenden.

Fessenden's comment regarding white lead is interesting. At the time when these batches were in use, white lead was prepared by the Dutch process in which the lead grids were suspended on shelves in fire-clay pots containing acetic acid in the glazed bottoms. The pots were stacked up and covered with tanbark. The acetic acid on evaporating partly attacked the lead and produced a fermentation in the tanbark, so that carbon dioxide was formed. As a consequence, in the presence of moisture, the grids were gradually converted to basic carbonate of lead [$2PbCO_3$, $Pb(OH)_2$], which was then crushed and pulverized. The basic carbonate decomposes at 400°C., and probably forms litharge. Red lead (Pb_3O_4) decomposes at 500°C. to form litharge (PbO). It is difficult to see why white lead should have an advantage over red lead, until one observes that Fessenden mixes gold solution with the white lead, which neutralizes the free acid.

Regulus of antimony (metal) and the trioxide are both employed in the batch. There is sufficient of the element to prevent complete oxidation by the potassium nitrate which is present. The reducing action which results from the use of metallic antimony is considered desirable in gold ruby glasses.

F 27-I. Large Batch of Ruby:

Sand	375 lb.
White lead	250 lb.
Potasse refined very fine	100 lb.
Salt Petre	12 lb. 8 oz.
Regulus of antimony	6 lb. 4 oz.
Oxide of antimony	2 lb. 8 oz.
Oxide of tin	3 lb. 8 oz.
Manganese	3 lb.
Oxide of iron	7 oz. 240 gr.
Gold in solution	6 oz. 240 gr.

"With this batch, I would use if I had it 200 lbs. of Ruby cullet. If you have not so much as that use what you have taking care that none of the pieces that have flint coated with ruby get among the ruby cullet."

This is not merely a larger portion of F 12-I, for the proportions of some of the materials are different.

F 54-I. Ruby, as made December 31, 1867:

Sand	170 lb.
Lead	220 lb.
Salt Petre	22 lb.
Ash	14 lb.
Slate	14 lb.
Black oxide antimony	4 lb.
Manganese	2 lb.

"One grain of gold to each pound of batch."
"Mix all the ingredients together excepting the sand. Add gold to sand, mix all together and fill at once. Batch made December 31 good strong color but not rich as our regular Ruby."

This is a strange batch indeed. Slate is an impure silicate of aluminum. There is no black oxide of antimony. Black antimony is a natural sulfide. There is brown oxide of antimony which consists of a mixture of trioxide and oxysulfide (Sb_2OS_2), principally the latter. It is a grayish brown powder.

F 55-I. Fancy Ruby in Grammes:

Sand	413 gr.
Lead	325 gr.
Ash	44 gr.
Salt Petre	64 gr.
Bicarb. soda	13 gr.
Black oxide antimony	6 gr.
Manganese	3 gr.

"Add requisite amount of gold to above."

Here black oxide of antimony is used again. The abbreviation gr. stands for grams in this batch, but for grains in all others.

F 62-I. Gold Ruby, G. S. P. recpt., March 1876:

Sand	300 lb.
Lead	200 lb.
Ash	80 lb.
Salt Petre	10 lb.
Reg. of antimony	5 lb.
White ox. of antimony	2 lb.
Manganese	2 lb.
Oxide of tin	2 lb.
Red oxide of iron	6 oz.
Gold in solution from	1 to 3 oz.

"Acid solution 4 pints muriatic acid; 1 pint nitric acid. Mix sand and all other ingredients except lead together Mix gold solution with the litharge or red lead and mix thoroughly, then mix all together."

The pouring of the gold solution onto the litharge or red lead may indicate that the author's guess about the use of white lead for neutralizing the acid in an earlier batch was wrong.

F 31-II. Gold Ruby for Casing (large batch):

Sand	150 lb.
White Lead	100 lb.
Refined ashes	40 lb.
Nitrate of potash	5 lb.
Regulus of antimony	2 lb. 8 oz.
Oxide of tin	1 lb.
Manganese	1 lb.
Oxide of antimony	1 lb.
Red oxide of iron, pure	3 oz.
Gold in solution	1½ oz.

This batch is not the same as F 12-I. Less gold is used.

F 32-II. Gold Ruby for Casing. Small reduced batch which will agree with the ordinary best English flint:

Sand	25 lb.
White lead	20 lb.
Refined ashes	8 oz.
Nitrate of potash	1 oz.
Regulus antimony	8 oz.
Oxide antimony	3 oz. 80 gr.
Manganese	3 oz. 80 gr.
Oxide of tin	3 oz. 80 gr.
Oxide of iron red	240 gr.
Gold in solution	200 gr.

Note how carefully the Sandwich batches were studied with reference to the use for casing other glasses.

F 33-II. Another Gold Ruby Casing batch which agrees with French Flint without Lead, etc.:

Sand	25 lb.
White lead	25 lb.
Refined ashes	8 lb.
Nitrate of potash	1 lb.
Regulus of antimony	8 oz.
Oxide of antimony	3 oz. 80 gr.
Manganese	3 oz. 80 gr.
Oxide of tin	3 oz. 80 gr.
Red oxide of iron	240 gr.
Gold in solution	180 gr.

F 34-II. Blood Ruby for Casing:

Sand	25 lb.
White lead	20 lb.
Refined ashes	8 lb.
Nitrate of potash	1 lb.
Regulus of antimony	8 oz.
Oxide of antimony	3 oz. 80 gr.
Manganese	3 oz. 80 gr.
Oxide of tin	3 oz. 80 gr.
Red oxide of iron	140 gr.
Black oxide of nickel	60 gr.
Gold in solution	240 gr.

Batch K 32 is marked Fessenden's Pot Ruby. In referring to it, note that green oxide of nickel was employed. Otherwise, there is no resemblance to the above batch. This employs black oxide of nickel. The so-called green oxide is a hydrated oxide. It is converted to the black oxide on heating.

F 35-II. Purple for Casing:

Sand	25 lb.
White lead	20 lb.
Refined ashes	8 lb.
Nitrate of potash	1 lb.
Regulus of antimony	8 oz.
Oxide of tin	3 oz. 80 gr.
Black oxide of nickel	300 gr.
Gold in solution	140 gr.

F 36-II. Another Purple for Casing:

Sand	25 lb.
White lead	20 lb.
Refined ashes	8 lb.
Nitrate of potash	1 lb.
Regulus of antimony	8 oz.
Oxide of tin	3 oz. 80 gr.
Green oxide of nickel	400 gr.
Gold in solution	100 gr.

The two preceding batches are alike except for the nickel compounds and the quantity of gold employed. Note that antimony trioxide has been omitted in both. Also, observe that in the second batch 400 grains of green oxide of nickel are used, while in the first there are 300 grains of black oxide. The proportions are fairly close to the relative molecular weights of the two compounds. The nickel compound assists in producing the purple color, although this may be obtained according to heat treatment without the nickel oxide.

F 17-I. Pink Enamel for Casing (Pompadour)

White enamel No. 13	18 oz.
Gold in solution	3 gr.
Oxide of tin	13 gr.

"When the Gold is dissolved put the tin into the solution and pour the solution over the batch."

This enamel was probably prepared in very small pots and either used for flashing crystal or Fessenden Enamel No. 13 which was referred to in installment two.

Copper Rubies

ALTHOUGH copper compounds were used for producing red glasses long before gold was employed, the gold rubies were so much richer in appearance and absorbed so little light by comparison that they were given preference in spite of their cost of manufacture and the added cost of preparing cased or flashed glasses. The copper rubies in the solid form absorb a large amount of light. They were also employed for casing or flashing at times, even as late as 1904 when a railroad semaphore was pressed of crystal glass and a thin copper layer blown upon it before the blank had a chance to set, so that the plunger could be lowered once more to affix the ruby firmly to the crystal.

Reducing agents are usually employed for the production of copper reds. When the glass comes from the pot it varies from an almost colorless appearance to a light amber. On reheating, a red color develops. A controversy exists between advocates of the cuprous-oxide and colloidal-copper theories concerning copper-red glasses. The matter is apparently unsettled.[8]

K 23. Cadogan's Copper Ruby:

Sand	16 lb.
Lead	8 lb.
Soda	4 lb.
Pearlash	4 lb.
Ammonia of copper	4 lb.
Tin	4 oz.
Iron scales	4 oz.
Copper	4 oz.

It is uncertain what Kern means by ammonia of copper. The writer ventures to guess that copper sulfate was dissolved in ammonia to obtain the blue complex $Cu(NH_3)_4SO_4$ and that this was introduced into the batch after evaporation. Copper batches still in use during the early part of the present century frequently contained ammonium carbonate, though its purpose is not clear. Some glass makers covered the batch after mixing and called attention to the fact that it warmed up when stored under a canvas. There was undoubtedly some reaction between the ammonium carbonate and batch ingredients. As pearl ash was employed in most of these batches, moisture was present, and as lime was sometimes employed, one could smell the liberated ammonia gas. At any rate, the glass makers thought that this heat or boiling, as they called it, was a factor in producing a successful glass.

Tin may have been introduced as powder or filings; it was usually introduced as the black stannous oxide. Iron scales were blacksmith scales (Fe_3O_4). The author has no recollection of ever having seen a batch in which metallic copper was used. Copper was usually introduced as black oxide (CuO) or, preferably, red oxide (Cu_2O).

K 41. Copper Ruby:

Cullet Best	20 lb.
Batch Best	10 lb.
Brass filings	10 oz.
Iron scales	7 oz.
Black antimony	2 oz.
Oxide of tin	2 oz.
Borax	12 oz.

"Added 2 oz. oxide of tin after the above was melted. Ladled out and added 3 oz. brass, ½ antimony, 2 oz. iron, 2 borax, ½ tin."

As lead batches were commonly employed for copper ruby at the Sandwich factory, it is assumed that Kern refers to flint cullet and flint batch. The author has never before seen a copper ruby batch in which brass fittings were used. Note that black antimony is mentioned again. The oxide of tin is probably stannic oxide. The batch was evidently fritted after preliminary melting and then the frit was mixed with the various other ingredients given in the note which follows the batch. This is a most unusual procedure.

Borax improves copper ruby glasses. This was evidently known to the Sandwich glass makers for they used it in the majority of batches of this type.

K 42. Copper Ruby:

Sand	14 lb.
Lead	8½ lb.
Putty	5½ lb.
Potash	4½ lb.
Sulphate copper	1 lb.
Sulphate iron	¾ lb.
Borax	8 oz.

It will be recalled that putty powder is an impure oxide of tin. The sulfates of copper and iron are employed. As no other reducing agent is indicated, it is likely that the sulfur dioxide produced through the thermal dissociation of the sulfates served as the reducing agent in the batch.

F 58-I. Copper Ruby:

Sand	12 lb.
Lead	3 lb.
Ash	4 lb.
Borax	1 lb.
Red copper	6 oz.
Tin	7 oz.
Sal tartar	4 oz.

Here we have the first reference to red copper, which probably means cuprous oxide. In the miscellaneous notes in his batch book Fessenden states "suboxide of copper is good for making copper ruby in combination with cream of tartar." An organic reducing agent is used for the first time. In copper ruby batches which have been in use in more recent years, charcoal, tartaric acid ($H_2C_4H_4O_6$), or "sal tartar" probably Rochelle salt

($KNaC_4H_4O_6 \cdot 4H_2O$) have been employed as reducing agents; also, potassium bitartrate, acid tartrate, or cream of tartar ($KHC_4H_4O_6$); also, flour and sugar. These char and produce carbon.

The reader of this installment must have been impressed once more with the versatility of the Sandwich glass makers. Their extensive knowledge of crystal, opal, and alabaster glasses was carried into the field of ruby glass manufacture. It is doubtful whether any author of books on glass making or any one of the more modern manufacturers possesses such a variety of batches or follows such a varied procedure in the manufacture of ruby glass.

Although a patent was granted in 1865 to the French chemist J. T. Pelouze for coloring glasses red through the use of selenium,[9] the glass makers at Sandwich were evidently uninformed. This is not surprising, for it is doubtful whether selenium ruby glass was made on a commercial scale even in Europe before the Sandwich factory closed in 1888.

The next installment will cover yellow and amber glasses.

[2] A. Silverman, "Colloids in Glass," J. Am. Ceram. S. **7**, 795 (1924).
[3] A. Neri, l'Arte Vetraria, Italy, 1612.
[4] W. D. Bancroft, "Applied Colloid Chemistry," p. 306. N. Y. (1920).
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NEW SAFETY GLASS BY PITTSBURGH PLATE

The development of a high test laminated safety glass, which after being cracked will stretch and bend upon further impact, has been announced by the Pittsburgh Plate Glass Co. The secret of this safety glass lies in the development of Vinal, a new plastic with rubber-like stretching qualities and extremely high tensile strength. It is said to be about 10 times as resistant to breakage as other safety glasses at 10 degrees below zero and five times as resistant at 70°F.

Vinal is composed of a synthetic resin of the vinyl group, called vinylite X, and a plasticizer designed to develop and control its physical characteristics. In addition to increasing elasticity and tensile strength, its use is also said to simplify the manufacture of safety glass by eliminating the necessity for edge sealing. It requires no heat for cutting the laminated glass nor adhesives for cementing it to the glass. It is reported impervious to discoloration by sunlight or decomposition by extreme atmospheric heat. Even when broken by a series of impacts, it may be rolled up like a rug with virtually no glass leaving the plastic or presenting sharp edges on the surfaces.

After more than six years of development and research, the new product represents a joint effort by the Carbide and Carbon Chemicals Corporation's research department at Mellon Institute and the Pittsburgh Plate Glass Company's Duplate research laboratory at Creighton, Pa.

EFFECT OF ALUMINA

(*Continued from page* 114)

The results of this investigation seem to justify the following conclusions, which apply to the base glass used and with the additions of alumina in amounts from two to eight per cent inclusive.

(1) Additions of alumina decrease the melting rate and its effect decreases with rising temperatures.

(2) If the final crystalline phase is silica, then the rate of solution is chiefly influenced by the viscosity.

(3) Insofar as solution time is concerned, the use of seven per cent alumina in ordinary soda-lime-magnesia-silica glasses would not be prohibitive.

GLASS COSMOSARIUM INVENTED

A model of a cosmosarium, a new kind of glass house, enables men to look at the world from the point of view of a philosopher with his head in the clouds. Plans for the cosmosarium call for a glass sphere with a diameter of 100 feet, with a model of the earth 20 feet in diameter revolving upon its axis in the center of the sphere. Binoculars to be placed at various observation points will enable the viewer to study parts of the earth as though he were on a cloud five miles above the earth. The model of the cosmosarium may be seen at the Hayden Planetarium of the American Museum of Natural History, New York.

The Technical News Bulletin of the National Bureau of Standards for March contains several items of interest to glass technologists. One of these items refers to the absorption of x-rays by lead and lead barium glasses. It is a summary of a paper which appeared in RP 870 of the Bureau's March Journal of Research. Another article refers to K_2O—PbO—SiO_2 glazes and glasses.

NEW CHEMICAL FORMULARY

Volume III of The Chemical Formulary has been brought out a year ahead of schedule because of many insistent requests. Many new technicians have contributed information said to be hitherto unpublished and unavailable. A comprehensive index of all three volumes is included so that reference is greatly simplified.

U. E. Bowes and J. T. Littleton returning from a turkey hunt. Mr. Bowes is carrying the turkeys and Dr. Littleton the guns. F. W. Preston shot both gentlemen with his trusty camera.

EQUIPMENT AND SUPPLIES

DRAKENFELD ANNOUNCES A NEW SCREEN ETCH

B. F. Drakenfeld & Co., Inc., New York, has announced a new and exclusive compound, called Screen-Etch. It is said to be possible, by using this compound, to etch signs, designs, patterns, etc., directly on the glass. The process is the same as for any screen process paint, except that the glass is washed after screening.

The product is marketed fully prepared in one pound containers, a pound being sufficient to produce 75 square feet of etched surface.

CATALOGS RECEIVED

The Channel Valve. Ingersoll-Rand Co., 11 Broadway, New York City. Fully illustrated and colorful booklet describing a new development in valve design. This new valve, in which a greater-than-usual portion of valve opening is utilized, is said to be of great importance to users of air and gas compressors.

Your New Plant: Multistory or Single Story—Which? The Austin Co., Cleveland. Relative costs and utility of a single story plant and a six-story building, each with 72,000 square feet, are charted. It is said that a single story plant saves up to 20 per cent of employees' time. An interesting study.

Clearlite. Fourco Glass Co., Clarksburg, W. Va. A folder in varied colors with many illustrations suggests the application of this glass for offices, factories, stores and automobiles.

Flame-otrol. Control Pyrometer. Small Indicating Pyrometer. Thermo Control Devices, Chicago. Three separate folders on various heat controlling apparatuses. Flame-otrol is an automatic gas shut off, and as with the other items listed above, is said to have a place in various ovens and furnaces.

Instruments for Crime Detection. Bausch & Lomb Optical Co., Rochester, N. Y. An extremely interesting booklet. While not of direct value to glass manufacturers, it points out the part which instruments utilizing glass are playing in fighting crime.

Silverstreak Silent Chain Drives. No. 1725. Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. A 32-page booklet with 30 illustrations have been published to describe the stock line of standard chain drives, ranging from ½ to 60 horse power. Complete details are tabulated for the wheels and chain on each drive, together with ratio tables and prices.

Chain Hoists. Bulletin HH2 and 101. McCollum Hoist & Mfg. Co., Downers Grove, Ill. Price lists and illustrations of chain hoists capable of lifting ¼ to 20 tons. No. 101 gives the revised prices of the Mac Improved Electric Hoists.

REMOTE CONTROL FOR VALVES

To supplement automatic control systems, Foxboro Co., Foxboro, Mass., has developed a new remote hand control for valves. This instrument mounted on a centrally located panel enables the operator to adjust manually the opening of an out-of-the-way inaccessible valve without moving from his station. He can reset a valve several hundred feet away to control temperature, pressure, flow or liquid level, using readings from his recording instruments to guide him.

A feature of this remote hand control is said to be the extreme precision with which valves may be set. A valve opening can be altered by as little as a few thousandths of an inch to produce the exact desired flow. Used in conjunction with the Foxboro Stabilflo valve, it is said that the controlled flow can be changed by less than one per cent.

Foxboro says that because of the original design of this apparatus, there is no pumping or vibrating, and air pressure on the diaphragm is held at exactly the desired setting. The instrument is finished in lacquered cast bronze trimmed with buff nickel.

NO MOVING PARTS IN SILENT SWITCH

A small compact electric switch, which is silent in operation and has no moving parts was introduced by the General Electric Co., Schenectady, N. Y., at the recent opening of the New York Museum of Science and Industry at Rockefeller Center, New York. The switch, which is about the size of a marble, utilizes the mercury-break principle. In tests at the Schenectady laboratory, one of these switches is reported to have turned a 200-watt on and off some 65 million times without failing or wearing out.

INCO EXPANDS FIELD SERVICE

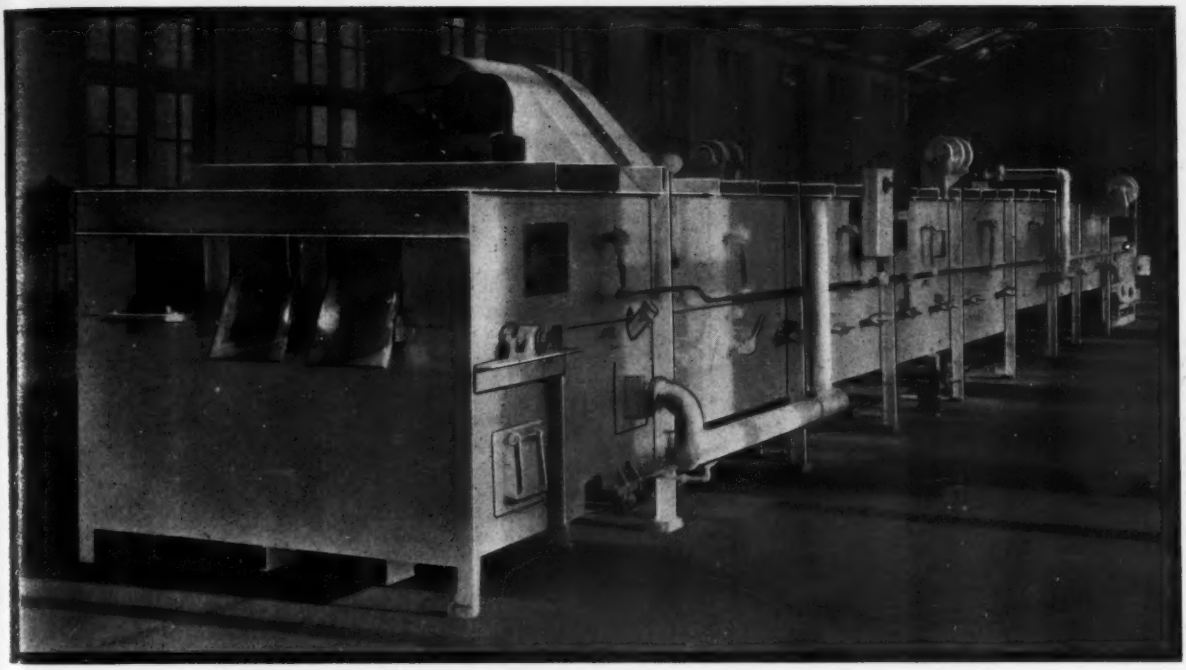
The International Nickel Co., Inc., New York, has expanded its technical field service with offices in Chicago and Los Angeles, equipped to furnish industry with information and assistance in connection with the production and utilization of nickel alloys. In Chicago, address H. L. Geiger, Room 1116, 333 North Michigan Ave. West Coast inquiries should be addressed to A. G. Zima, 705 Petroleum Securities Building, Los Angeles.

NEW COMBINATION SET OF PYROMETERS

An unique combination set of surface and needle pyrometers has been placed on the market by the Pyrometer Instrument Co., New York. By merely interchanging the various types of thermocouples, a matter of a few seconds, the instrument may be transformed into four different types of surface and needle pyrometer. The new indicator is equipped with a patented clamping device whereby contact and reading of temperature no longer have to be made simultaneously. The indicating needle is said to stay fixed at the temperature indicated.

A NEW LIGHT HOIST

The Harnischfeger Corporation, Milwaukee, has announced an entirely new line of electric hoists, called Zip-Lifts, which have capacity ratings of 250 to 500 pounds. Designed primarily for spot handling work, these all-welded units are exceptionally light, the quarter ton model weighing only 100 pounds.



SOLVING NEW PROBLEMS FOR THE GLASS INDUSTRY

● During the past year production men in the glass industry have faced many new problems, such as annealing at higher temperatures, melting special glasses at higher temperatures with increased flexibility, glass heat treating to accomplish certain definite results in the finished product.

These new problems in production have raised corresponding and related problems in equipment—the proper selection of structural materials to withstand higher temperatures, increased flexibility in heat distribution, improved temperature and atmosphere control.

As indicated by the photographs of some recent SC installations shown above, production men in the glass industry have turned to Surface Combustion as an organization with laboratory and manufacturing facilities, with engineering experience and personnel, schooled in the solution of heat treating problems for industry. They have found there an understanding and appreciation of their problems and needs, and an ability to interpret engineering facts into practical furnace construction, which includes the selection of proper materials, the determination of proper sizes, the designing and construction of practical furnaces for special needs as well as for regular production requirements. The satisfactory results obtained in actual operation are now a matter of production records.

Surface Combustion developments are available for finishing and conditioning, as well as for melting and annealing. May we tell you how you can investigate these new developments for yourself?

WHAT IS *Your* PROBLEM?

Do you need equipment to:

- Anneal at higher temperatures
- Melt Special Glasses at higher temperatures
- Accomplish unusual results in finished product
- Anneal ware traveling at different speeds in same lehr
- Heat glass from cold for hardening
- Heat glass for molding
- Anneal glass requiring different temperatures in same lehr at same time
- Anneal special ware on high speed conveyors
- Anneal optical glass
- Increase annealing capacity with limited space for lehr

Whatever the job to be done—whether it ever has been done before or not—if it has to do with heat treating, submit it to SC Engineers.

SC LEHR
THE ONLY LEHR WITH
Controlled Recirculation

Surface Combustion Corporation

TOLEDO, OHIO (SC) *Sales and Engineering Service in Principal Cities*

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.	...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	...	Po. or Gr. .25 / Cry. .25½
Aluminum hydrate (Al (OH)3)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.14½
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¼
Antimonate of Sodium	lb.	.12¼	.13¼
Antimony oxide (Sb_2O_3)	lb.	...	.13¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¼
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
(Commercial, 25% Selenite)	lb.	16.00	.90
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	1.00-1.10
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_3O_4) In bbls.	lb	...	1.29
In 10 lb. tins	lb.	...	1.39
Copper oxide Red (Cu_2O)	lb.	...	.20
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09¼
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar— 20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.07	...
In 5 Ton lots	lb.	...	.075
Less than 5 Tons	lb.	...	.08

		Carlots	Less Carlots
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75	...
Litharge (PbO) (New York Prices)	lb.	.06	...
In 5 Ton lots	lb.	...	.065
Less than 5 Tons	lb.	...	.07
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0265
Manganese, Black Oxide In Paper bags	ton	50.00	52.50-55.00
In Burlap bags	ton	51.50	54.00-56.50
In Casks	ton	53.00	55.50-58.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00 29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.09
Powdered	lb.	...	.09½
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.06¾	.07¾
Hydrated 80-85%	lb.	.06	.06¼-.06¾
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	...	.29
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17½-.18¼
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	...	Po. or Gr. / Cry. .13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.)	per oz.	...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.07
Sodium chromate ($Na_2CrO_4\ 10H_2O$)	lb.	...	.08¾
Sodium fluosilicate (Na_2SiF_6)	lb.	.05¾	.06¼
Sodium hydrate ($NaOH$) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97% Bulk	Per 100 lb.	1.225	...
200 lb bags		1.29	1.34
100 lb. bags		1.325	1.375
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50 1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.36½
Tin oxide (SnO_2) in bbls.	lb.	...	.51
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.60
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO) American process, Bags	lb.	.05	.05¼
White Seal, 150 lb. bbls.	lb.	.06¾	.07
Green Seal bags	lb.	.06	.06¼
Red Seal, bags	lb.	.05½	.05¾
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04-.05

For Glassmen Only

THE GLASS INDUSTRY is edited exclusively for glassmen . . . production managers, technologists, and controlling executives. THE GLASS INDUSTRY gets closer to vital problems of glass manufacture than does any other publication.

Strict adherence to the publishing formula of editing *for glassmen only* has won a place of leadership for THE GLASS INDUSTRY.

The Glass Industry

233 Broadway New York City

NOTES ON EUROPEAN GLASS

(*Continued from page* 126)

benefited from a well sustained demand through the year, and part of the existing stocks could be absorbed, while prices were increased by 10 per cent after the devaluation. At the end of the year the heavy building activity resulted in the seasonal slump being less severe than in recent years. The production of plate glass for 1935 amounted to 1,867,768 square yards, against 1,827,768 square yards during 1934.

The glassware industry, which was much depressed before the devaluation, subsequently showed considerable improvement, reaching a production capacity of 65 per cent. At the instigation of the Government, a Cartel was established, grouping 25 plants, with only two firms, representing less than 5 per cent of the total production, remaining outside. Seven of the 25 factories were closed and were paid an indemnity from the other producers. They will be reopened if the volume of orders continues to increase. Prices for the local market have been increased by 5 per cent only for current articles. Exports are subject to license, in accordance with the "Marchandeau-van Zeeland Agreement" for Belgian exports, since most foreign markets are still dominated by keen international competition and by quota and license restrictions; and discretion is necessary to prevent retaliation.

The Belgian manufacturers of pressed glass have also established a Cartel and have requested Government intervention for the regulation of production and distribution.

BELGIANS ASK FAIR TRADE IN BOTTLES

The Belgian Syndicate of Glass Flask and Bottle Makers have asked the Ministry of Trade for legislation to regulate both production and selling in that industry. Concrete proposals have already been made to avoid unsound competition and misleading claims as to quality, content or origin of perfumery and similar glass containers.

DUTCH GLASS FIRM BUYS CITY

Continental Glass Manufacturing Co., The Hague, Holland, has recently purchased Durant City, Pa., a factory city erected by the defunct Durant Motor Co. This plant, once valued at $4,000,000 is reported to have been purchased for $20,000 of which $15,000 represented past due taxes. Following Durant's failure, the plant was operated for a while by the Kane Glass Factories Co. While future plans have not yet been announced, Mr. Sullivan reports that the Dutch firm will utilize the plant and city for the manufacture of products in which it is interested. The Continental is interested in plate glass, safety glass and special glass products.

NEW JERSEY CERAMISTS TO EXHIBIT

The Ceramics Department of Rutgers University and the Ceramic Association of New Jersey will hold its Fourth Ceramic Exposition, April 24 to May 3, in the Ceramics Building, Rutgers University, New Brunswick, N. J. The exposition will be open to the public, free admission, from 2 P. M. to 9 P. M. daily, with the exception of Sunday. Further information may be obtained from George H. Brown, director, Department of Ceramics, Rutgers University, New Brunswick, N. J.

DESIGNS
MODELS
MOULDS
MOULD CASTINGS
Quality and Quick Service
....350 EMPLOYEES
OVERMYER
MOULD COMPANY
WINCHESTER
IND.

Old established firm of Glass Merchants in England wish to acquire, either by purchase outright, or on royalty basis, complete plant and process for the manufacture of .... "TEMPERED" (heat treated) PLATE GLASS also SAFETY GLASS (Laminated). Must be well tried and of first class commercial value.

Director of Company will shortly be visiting U. S.

REPLIES TO BOX 27—THE GLASS INDUSTRY